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FARMERS' BULLETINS
Nos. 926-950,

WITH CONTENTS AND INDEX.

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SOME COMMON DISINFECTANTS

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Chief of the Biochemic Division

FARMERS' BULLETIN 926

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Animal Industry

A. D. MELVIN, Chief

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THE word "infected" means contaminated with or affected by disease germs; "disinfected" means freed of disease germs. A "disinfectant" is a product that destroys disease germs or renders them harmless. An "antiseptic" is a substance that prevents the development and growth of disease germs, but an antiseptic is not a disinfectant unless it is capable of destroying disease germs in addition to preventing their growth.

A disinfectant is not necessarily an "insecticide," for some powerful disinfectants are relatively harmless for insects and the best insecticides may be of little value as disinfectants.

Formaldehyde is one of the most powerful disinfectants known, but it is a very weak insecticide; and, conversely, hydrocyanic acid is deadly for insects and all forms of animal life, while it has little power as a germicide or disinfectant. It is well to remember also that "deodorants" are not necessarily disinfectants—one destroys odors, the other destroys germs.

No single disinfectant is appropriate in all cases. Select the proper substance, apply liberally, allow ample time for the disinfectant to do its work, and remember that success depends in large part upon the care and exactness of the person who prepares and applies the disinfectant.

SOME COMMON DISINFECTANTS.[1]

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NEED OF INFORMATION ABOUT DISINFECTANTS.

THERE is much popular misconception regarding the value and limitations of disinfectants. The efficacy of disinfectants is largely dependent upon the mode of application and the kind of material to which they are applied, therefore some knowledge of disinfectants and of their limitations is necessary to obtain the desired results.

In this paper no attempt is made to cover the entire field, but rather to indicate, briefly, the properties and uses of some of the disinfectants that are commonly used about the household and the farm.

FORMALDEHYDE.

Formaldehyde, also called "formic aldehyde," may be obtained on the market in two forms. The one, a sort of condensed formaldehyde, is known as "paraform," and is sold as a white powder or in the form of compressed tablets or pastils. The other is a strong solution of formaldehyde in water and is generally known under the name of "formalin," or solution of formaldehyde. The solution contains from 37 to 40 per cent of formaldehyde.

For practical disinfection the formaldehyde is applied either in the form of gas or vapor or in solution in water. It is most commonly used in gaseous form.

DISINFECTION WITH FORMALDEHYDE GAS.

Gaseous formaldehyde rather than the solution of formaldehyde is commonly employed in cases where the furniture or interior decorations of rooms would be injured or where the value of materials, such as hay and fodder, would be lessened by wetting. In disinfecting with formaldehyde gas it is essential that a sufficient quantity of gas be liberated and that it be held within the compartment that is to be disinfected for a sufficient length of time to accomplish the destruction of the germs of disease. The gas escapes very readily through any openings or crevices around windows, doors, or elsewhere. Hence it is essential that compartments to be disinfected by formaldehyde gas be tightly closed and that all openings be sealed during the period of disinfection. It is well to remember also that the temperature is an important factor in disinfecting with gaseous formaldehyde, as this disinfectant is much more energetic in a warm atmosphere than in a cold. If the temperature is much below 65° F., disinfection with gaseous formaldehyde can not be relied upon under ordinary circumstances. It is desirable also that the air be moist, and precautions in this respect should be taken in dry weather. In cold weather compartments should be heated.

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[1] This is a revision of Farmers' Bulletin 345.

Various forms of apparatus have been designed for generating formaldehyde gas. Some of these produce the gas from wood alcohol; others are designed to liberate gas by heating solid formaldehyde (paraform), while still others merely volatilize the formaldehyde solution. While these various methods are effective, they require special generating apparatus and are no more effective than simpler means which have now generally replaced the more expensive and complicated processes. The two methods most generally used for applying formaldehyde gas are the spray method and the potassium permanganate method.

SPRAY METHOD.

The spray method is best suited for use in small compartments, such as chests and closets. The commercial 40 per cent solution of formaldehyde is used. This is sprayed directly into small chests and closets, and in the case of small rooms the solution is sprinkled upon a sheet which has been suspended in the room for the purpose. An ordinary sprinkling can, such as is used for watering flowers may be used for spraying the solution of formaldehyde. At least 10 ounces of the solution should be used for each 1,000 cubic feet of space in the room. After spraying the formaldehyde the room or compartment should be quickly closed, keyholes and apertures sealed, and allowed to remain so far at least eight hours.

POTASSIUM PERMANGANATE METHOD.

The potassium permanganate method has now come into quite general use for disinfecting rooms and large compartments. It is carried out by pouring 40 per cent solution of formaldehyde upon crystallized or powdered potassium permanganate. A violent chemical reaction takes place immediately. Heat is generated and formaldehyde in gaseous form is rapidly liberated. The heat is caused by the reaction between the formaldehyde and the potassium permanganate, and a considerable proportion of the formaldehyde is consumed by this reaction. It has been found that the quantity of gas evolved depends in great measure upon the relative weights of permanganate and of formaldehyde solution that are used. Experiments have shown that the most favorable proportions are 6 parts by weight of 40 per cent formaldehyde solution to 5 parts by weight of chemically pure permanganate of potash. With these proportions approximately 50 per cent of the formaldehyde is liberated in the form of gas.

Allowance must be made for the loss of formaldehyde due to the chemical reaction when arranging for disinfection by this method. As approximately 10 ounces of formaldehyde solution is required for the disinfection of 1,000 cubic feet of space, it is necessary when this method is employed to use twice as much. In practice, therefore, for disinfecting 1,000 cubic feet of space, use 20 ounces of formaldehyde solution by weight to 16⅔ ounces of potassium permanganate. The needle-shaped crystals of the permanganate should be employed.

To disinfect a room, place the required amount of permanganate in a wide-bottom bucket or basin with flaring sides. An ordinary dishpan will serve the purpose well. The pan should be raised a short distance from the floor by means of a box or bricks to prevent injury to the floor from the heat, and it is desirable also to protect the floor for some distance around the pan by means of paper or otherwise, as sputtering during the reaction may cause some of the chemicals to splash entirely out of the container. This is less likely to occur if the vessel has good depth.

When everything has been made ready the requisite amount of 40 per cent formaldehyde solution should be poured upon the permanganate, which should have been previously placed in the container, and the room should then be quickly closed and sealed. It should remain closed for at least 8 hours, and a considerably longer period is better in order to assure thorough disinfection. It should be remembered that formaldehyde gas does not penetrate deeply into articles; that it will not quickly enter bureau drawers, closets, and other compartments within the room unless they are opened wide and arranged so that the gas may have free access to them. The same applies to clothing and draperies, which should be hung loose and free in the room. Crevices and cracks around windows, doors, and elsewhere are most conveniently closed by pasting strips of paper over them. All openings into the room should be thus closed except the one through which exit must be had after starting the disinfection. The crevices about the exit can be closed as above indicated after retiring from the room.

DISINFECTION WITH FORMALDEHYDE SOLUTION.

The solution of formaldehyde is a most excellent and reliable disinfectant. For general purposes it is best used by making a 10 per cent solution in water, that is, 10 parts of the 40 per cent solution of formaldehyde made to 100 parts with water. Small objects which will not be injured by wetting may be immersed in the solution. It does not affect metals injuriously except after prolonged action. It is an excellent deodorant as well as a disinfectant and may be usefully employed for disinfecting small areas around the house or stable, for disinfecting discharges from the sick room, and in numerous other ways. It tends to harden skins and render them brittle, and is therefore not suited for the disinfection of furs, but ordinary fabrics are not injured and it usually has little effect upon colors.

ADVANTAGES AND DISADVANTAGES OF FORMALDEHYDE.

The advantages of formaldehyde may be summarized as follows:

1. It is one of the most powerful germicides known.
2. Its action is not hindered greatly by albuminous substances or organic matter.
3. It is not poisonous.
4. It is not injurious to delicate fabrics, to paint, or to metals. (Prolonged contact will affect iron, but not other metals.)
5. It is the only known gaseous disinfectant which can be used effectively and safely in households.

The disadvantages of formaldehyde are as follows:

1. The gas has a strong tendency to condense in cold weather, and it is not reliable as a disinfectant when the temperature of the air is much below 65° F.
2. It has a very penetrating odor, and the gas is irritating to the eyes and nose.
3. To accomplish disinfection by the gas a long period of exposure is necessary and considerable work is required in the proper sealing of rooms which are to be disinfected.

CARBOLIC ACID (PHENOL).

The term "carbolic acid" has been rather loosely employed to designate a variety of substances which, though related chemically, are yet quite different in their disinfecting properties. The true carbolic acid, or phenol, as it is more properly termed, when in a pure state is solid at ordinary temperatures and when freed of water crystallizes in long white needles. Owing to their property of absorbing water from the air the crystals are likely to form a solid cake in bottles and other containers. For this reason carbolic acid is usually dispensed from drug stores in a liquid form prepared by adding 1 part of water to 9 parts of the crystals. The pure carbolic acid is not well suited for disinfection on a large scale on account of its cost. It is also not so powerful as other disinfectants which may be obtained at a smaller cost.

A 5 per cent solution of pure carbolic acid is a very satisfactory disinfectant for sputum or for discharges from the sick room, and a 2 per cent solution for disinfecting the hands. Fabrics may be disinfected by immersion in a 5 per cent solution for one hour. Carbolic acid does not seem to have the power of killing the germs of certain diseases, such as smallpox and hog cholera, but for most of the ordinary bacteria it is quite effective. Large surfaces are best treated by spraying with a 5 per cent solution. Neither carbolic acid nor other related disinfectants, such as crude carbolic acid, cresol, etc., are suitable for use in refrigerators or compartments where foods are stored nor in barns where dairy cows are kept, for the reason that all food products tend to take up carbolic acid from the air and acquire a disagreeable taste and odor which renders them unfit for food. It should be remembered, likewise, that carbolic acid is one of the most virulent of poisons, and that it is dangerous to leave it around the house in concentrated form.

ADVANTAGES AND DISADVANTAGES OF CARBOLIC ACID (PHENOL).

The advantages of carbolic acid are:

1. It is reasonably effective for destroying most of the common bacteria.
2. Its action is not greatly hindered by organic matter.
3. In a 5 per cent solution it does not materially injure metals or fabrics after contact for one hour or less.
4. It is readily available at all drug stores.

The disadvantages are:

1. It is not effective against all forms of bacteria.
2. It is expensive.
3. It is very poisonous.

CRESOL.

Cresol is found on the market in varying degrees of purity. It is known also under a variety of names, such as tricresol, cresylic acid, liquid carbolic acid, straw-colored carbolic acid, etc. It is a clear, oily liquid and varies in color from light straw to a rather deep reddish brown. It has a strong odor resembling that of pure carbolic acid, and like carbolic acid is quite corrosive when in concentrated form.

The cresol of commerce consists of a mixture of closely related bodies, all of which are superior to pure carbolic acid as disinfectants. It differs from "crude carbolic acid" in being practically free of coal-tar oils. Commercial grades usually contain from 90 to 98 per cent of cresylic acid or tar acids, and they may be purchased under guaranty of a definite degree of purity. Grades which contain less than 90 per cent of cresylic acid are not so desirable as those of greater purity, for coal-tar oils, generally found in the less pure grades, interfere with the solution of the cresol in water. Under ordinary market conditions cresol is relatively cheap and therefore well suited to the disinfection of cars, barns, and yards. Cresol may be used in the same way as pure carbolic acid, though it is considerably more powerful as a disinfectant and is therefore employed in a weaker solution. Roughly a 2 per cent solution of cresol may be regarded as equivalent to a 5 per cent solution of pure carbolic acid.

In preparing solutions of cresol, allowance should be made for the impurities. Cresol is not readily soluble in water, therefore warm water should be used in making solutions and care should be taken to see that all cresol is dissolved before the disinfectant is used. Cresol is quite poisonous, though less so than pure carbolic acid. While cresol is a more effective disinfectant than carbolic acid, its difficult solubility is a rather serious drawback; therefore, compounds of cresol with soap, which are readily soluble, are better than pure cresol for household and farm use. Many mixtures of cresol with soap are on the market under a variety of names.

COMPOUND SOLUTION OF CRESOL.

The compound solution of cresol is described in the United States Pharmacopœia. Any drug store should be able to prepare it. It is a mixture of cresol with a soap made of linseed oil and potash or soda. This compound solution of cresol is a thick, clear, dark-brown fluid which mixes readily with soft water in all proportions to form a clear, soapy solution. It does not mix well with hard water because the mineral salts in the hard water cause the soap to break up and separate in sticky masses.

A very efficient substitute for the compound solution of cresol may be made from commercial cresol or liquid carbolic acid of known strength by mixing these with ordinary green soap, which is purchasable at all drug stores. Making due allowance for any impurities that exist in the cresol which is used, the green soap is dissolved directly in the cresol, using equal parts of actual cresol and green soap by weight. The cresol is warmed and the soap stirred until it is thoroughly dissolved.

Substitutes for compound solution of cresol are prepared and sold by companies dealing in disinfectants. In many of these soda is used to replace, in whole or in part, the potash, which is much more expensive. The concentrated disinfectant when purchased already prepared should, if of good quality, be entirely homogeneous in composition. It should be readily and completely soluble in cold distilled water, and the solution should be practically clear and contain no globules of undissolved oil or cresol.

Compound solution of cresol is used in 2 or 3 per cent solution. The United States Bureau of Animal Industry recommends a solution prepared by dissolving 4 ounces in one gallon of water for disinfecting cars, boats, other vehicles, and premises.

ADVANTAGES AND DISADVANTAGES OF COMPOUND SOLUTION OF CRESOL.

The advantages are:

1. Weight for weight it is much more efficient and is cheaper than pure carbolic acid.
2. It is effective against hog cholera, whereas pure carbolic acid is ineffective.
3. It is very readily soluble.
4. Its soapy character permits good contact with greasy surfaces.

The disadvantages are:

1. It can not be used around compartments where foods are kept because of its odor.
2. It does not mix with hard water.
3. It is poisonous, though much less so than carbolic acid.

CRUDE CARBOLIC ACID.

Crude carbolic acid is a dark, oily fluid that is obtained during the distillation of coal tar, and usually contains little or no true carbolic acid. It has been widely used in this country as a household and farm disinfectant. Essentially, crude carbolic acid is a mixture of oils and "tar acids." The oils are practically devoid of disinfecting power, while the tar acids possess approximately the same disinfecting properties as cresol, to which they are closely related chemically.

Crude carbolic acid of commerce varies greatly with respect to the percentage of tar acid which it contains. Accordingly the disinfecting power will also vary, and crude carbolic acid should be used only when the content of tar acid, or cresylic acid, is known. Even then it must be regarded as of doubtful efficiency if the percentage of oils is relatively large, for the oils will to a great extent prevent solution of the acid in the water when crude carbolic acid is diluted for use as a disinfectant.

The strength of solution required will depend upon the amount of "acid" in the crude carbolic acid. Enough water should be added to produce a 2 per cent solution of tar acid. Thus, crude carbolic acid containing 50 per cent tar acid should be diluted by adding 1 part to 25 parts of water. Thorough stirring is necessary to bring about complete solution of the tar acid. The oils are insoluble and will float when mixed with water. The disinfecting solution prepared in this way is best applied by means of a spray pump. During the spraying the solution should be agitated so as to effect an even distribution of the oils, which always contain some undissolved tar acids.

There are on the market certain products which are sold under such names as liquid carbolic acid, straw-colored carbolic acid, etc., which should not be confounded with crude carbolic acid. These as a rule contain from 90 to 98 per cent of cresylic acid (tar acid), and are practically free of the oils. These purer products have been referred to in the description of cresol.

There is little to be said in favor of the use of crude carbolic acid as a disinfectant. Its composition is generally uncertain, and it possesses no advantages over other disinfectants, which, considering their power and their ready availability, are to be preferred.

EMULSIFIED COAL-TAR DISINFECTANTS.

The emulsified coal-tar disinfectants are found widely distributed on the market and are sold in cans or bottles of different sizes under a great variety of trade names. They are prepared from coal-tar products and consist of coal-tar oils and tar acids with soap. The product as purchased is a very dark, thick fluid, which should be of uniform consistency throughout. When mixed with water a milky emulsion is formed.

The disinfecting power of the products on the market varies greatly. There is no trustworthy method of determining their relative values by chemical analysis, so a method of comparing them by tests on typhoid-fever germs has been worked out. The power of carbolic acid to kill these germs under certain conditions is worked out in the laboratory, and after tests of the emulsified coal-tar disinfectants have been made under the same conditions their disinfecting power is expressed in the form of a comparison with carbolic acid. This is called the "carbolic-acid coefficient." If the coal-tar disinfectant is five times as effective as carbolic acid it is said to have a carbolic acid coefficient of 5. As a matter of fact, some of these preparations have a coefficient of cnly 0.5, while others have a coefficient of 20. The user of these products will do well to purchase only those that have a guaranteed carbolic-acid coefficient.

In general these emulsified coal-tar disinfectants have the same uses and properties as carbolic acid and compound solution of cresol, though less poisonous than either. Most of them may be used in a strength of 1½ or 2 per cent.

LIME.

Ordinary quicklime is one of the best and cheapest of disinfectants. It is not commonly applied in the form of quicklime, but in the form of a thick mixture with water known as "milk of lime." The lime is first slaked by adding 1 pint of water to 2 pounds of quicklime. Considerable heat is generated by this mixture, due to a chemical union of the lime and the water, which forms the hydrate of lime, or water-slaked lime. The development of heat and the crumbling of the hard lumps of quicklime are indications that the lime is of good quality and that it will make a satisfactory milk of lime.

The milk of lime is obtained by adding 4 volumes of water to 1 of the slaked lime and mixing thoroughly. Lime that has been exposed to the air for a long time becomes "air slaked"; that is, it takes up moisture and carbonic acid from the air and is converted into carbonate of lime, which is the same as marble and almost totally worthless as a disinfectant. After quicklime has been slaked with water, the slaked lime and any stock solution of milk of lime that may have been prepared should be kept in tightly closed containers to prevent deterioration, which will result from the action of the air. Whitewash is prepared by adding water to milk of lime until a mixture of suitable density is obtained.

Quicklime may be scattered about yards and lots, and the milk of lime is a good disinfectant for sick-room discharges. It should be added to urine or excreta in liberal quantity and allowed to remain in contact with these discharges for two hours before they are disposed of. Whitewashing of fences, pens, and the interior of outhouses serves to render them more sanitary as well as more attractive in appearance. Lime is well suited for use about dairy barns on account of the lack of any odor. It is preferable to chlorid of lime for that reason.

The advantages of lime as a disinfectant consist in its ready availability and cheapness. It is not, however, a reliable disinfectant against the most resistant forms of germ life such as the spores of the anthrax bacillus.

CHLORID OF LIME.

Chlorid of lime, commonly known as "bleaching powder," but more correctly designated "chlorinated lime," has been in common use for many years. It is a white powder that gives off the disagreeable odor of chlorin. It should be kept in hermetically sealed containers, as exposure to the air causes it to deteriorate rapidly. The efficacy of chlorid of lime is largely dependent upon the amount of available chlorin that it contains. The United States Pharmacopœia requires that at least 35 per cent of chlorin should be present in available form.

While chlorid of lime is a very powerful disinfectant, its potency is immediately and greatly reduced when it is brought into contact with organic matter. This is because the available chlorin combines quickly with the organic matter and is thus diverted from its desired action upon the germs. In applying chlorid of lime to the disinfection of sick-room discharges, manure, etc., it is important to add it in considerable excess so as to make allowance for the chlorin that will be used up by the organic matter. Besides being a good disinfectant, chlorid of lime is a powerful deodorant.

Chlorid of lime is only partly soluble, therefore in preparing it for use it is well first to rub it up well with a little water so as to break up the lumps, finally diluting to the desired volume. For general household and farm use, 6 ounces of chlorid of lime are mixed with 1 gallon of water.

The uses to which chlorid of lime may be put are restricted because of its corrosive action and its odor. It is a powerful bleaching agent and corrodes metals. Its odor is apt to be absorbed by meat, milk, and other food, and for these reasons its use is not recommended about ice boxes, cellars, or compartments where food is stored or in dairy barns.

BICHLORID OF MERCURY.

Bichlorid of mercury is known also as mercuric chlorid and corrosive sublimate. It is usually sold in the form of tablets in which the bichlorid of mercury is combined with ammonium chlorid which facilitates solution in water. The bichlorid has long been known to be a very powerful disinfectant. However, its power is greatly reduced when it is applied to solutions or substances containing large amounts of organic matter. Bichlorid of mercury is included with other common disinfectants in this bulletin more for the purpose of a warning against its use than for recommending it. It is extremely poisonous and therefore dangerous to have about the house. Many accidents have occurred through its use. It is nothing like so effective or so satisfactory for household use as many of the other disinfectants already described. It tends to attack metals. For these reasons it is not to be recommended as a household disinfectant.

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FARM HOME CONVENIENCES

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FARMERS' BULLETIN 927

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the States Relations Service
A. C. TRUE, Director

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" WHATEVER LESSENS WOMAN'S WORK BENEFITS THE RACE."

CONSERVATION of time and energy is obviously one of the problems of the housekeeper. Time and strength may be saved in two ways, first by taking thought as to the way one uses strength, and second by making use of labor-saving equipment. This may easily make the difference between a tired, overworked housekeeper and one who has some time and energy left for reading and recreation after the day's work is done.

Home conveniences have already been installed in several thousand country homes under the direction of State and county home demonstration agents. This phase of demonstration work has not only effected a real saving in the work of the home, but it is helping the farm woman to get a greater amount of happiness out of her daily tasks.

The household conveniences described in this bulletin have been selected because they may be made at a moderate cost by anybody who has a few simple tools and the ability to use them. Their use also yields a large return in comfort, economy, and sanitation.

Valuable suggestions have been secured from State publications and from the experiences of State and county home demonstration agents.

FARM HOME CONVENIENCES.

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THE KITCHEN CABINET.

A CARPENTER WITHOUT HIS BENCH loses much time in getting the right tools and in putting them away. A chemist can not do systematic laboratory work without a well-arranged desk. A kitchen cabinet is just as important to the housekeeper as the bench to the workman or the laboratory desk to the chemist. With it the housekeeper can sit down comfortably with her whole kitchen workshop within easy reach. It saves walking to and fro to gather up this thing and that, to prepare the food. Every kitchen should have a stool of the right height to enable the worker to sit at her work at the cabinet. The homemade cabinet shown in the illustration (fig. 1) is sanitary, convenient, and attractive. It is especially convenient and compact for kitchens in which space is limited.

A homemade cabinet can be built with moderate expense if outside labor need not be employed. If both lumber and labor must be purchased, the cost will equal that of a ready-made cabinet. The cabinet must be made of good wood, well seasoned. That is the most important consideration. Poorly seasoned wood warps and swells and is a constant annoyance in opening and closing doors and drawers.

The cabinet shown in the illustration is 6 feet 3 inches high to the top of the closet, 31 inches high to the top of the table. It is 21 inches deep and 48 inches wide. The part of the cabinet below the table contains the flour bin, large drawer, rack, and dough or pastry board. The bin is fastened to the frame with loose-pin hinges. By removing the pins the entire bin can be removed, cleaned, and replaced. The bin can be lined with tin to make it moisture, insect, and mouse proof. The dough board should be made of a wood that is tasteless and odorless and should be fitted well in the opening just below the table. A batten is tongued and grooved on each side of the board to prevent it from warping. The roomy drawer can be used for small utensils. The open space below the drawer can be occupied by the kitchen stool or the homemade fireless cooker when they are not in use.

Pie pans, lids, and covers have a most convenient place in the rack below the drawer. A drop table 21 inches wide and 19 inches long increases the table surface. This table is supported by inexpensive folding brackets.

The upper part of the cabinet consists of a closed compartment, three drawers, three open shelves, knife rack, and row of screw hooks for hanging utensils. The closed compartment is for package goods and large utensils. The drawers are for kitchen linen and other things needed in daily use. The lower shelf is 5 inches in depth, while the upper shelves are 7½ inches. On these shelves are kept coffee, tea, sugar, and spice jars. Three inches below the lower shelf there is a strip 1½ inches wide which holds the screw hooks. The knife rack is made by sawing slashes 1 inch deep in a piece of material 2 inches wide.

The cabinet is finished with two coats of white paint and one coat of white enamel. It can be easily kept clean and sanitary. Metal or wooden handles may be used.

THE FIRELESS COOKER.

Fireless cookers are now being made and used in hundreds of country homes. What is more pleasing to the farm woman than to put her dinner in the fireless cooker before she drives to town to market her products, and upon returning find it is ready for serving?

The fireless cooker offers several advantages. The first is economy of time, as the housekeeper may leave the food cooking without worrying about the results while she is engaged in other household duties or visiting her friends.

Some foods are improved by long cooking at relatively low temperature. The texture and flavor of tougher cuts of meat, old, tough fowl, and ham are improved by slow cooking. Cereals, dried legumes, and dried fruits are more palatable and wholesome when cooked for a long time. Soups and stews are delicious when cooked in the cooker. Baking, however, can not be done very conveniently and satisfactorily in the ordinary homemade fireless cooker.

In some sections of the country economy of fuel must be an important consideration. The food for the cooker may be started on the wood or coal range when the morning meal is being prepared. In warm weather the use of a fireless cooker and a kerosene stove means not only economy of fuel, but also comfort.

The food to be cooked is first heated to boiling point on the stove in the cooking vessel and then this vessel, covered with a tight lid, is quickly placed in the cooker, where the cooking continues. The cooker is so constructed that the heat does not escape. For long cooking it is necessary to place in the cooker under the cooking vessel a hot radiator. A soapstone is the best radiator and can be purchased at most hardware stores for 50 cents. A stove lid, a brick or disk made of concrete, heated and placed in the cooker, may serve as the radiator.

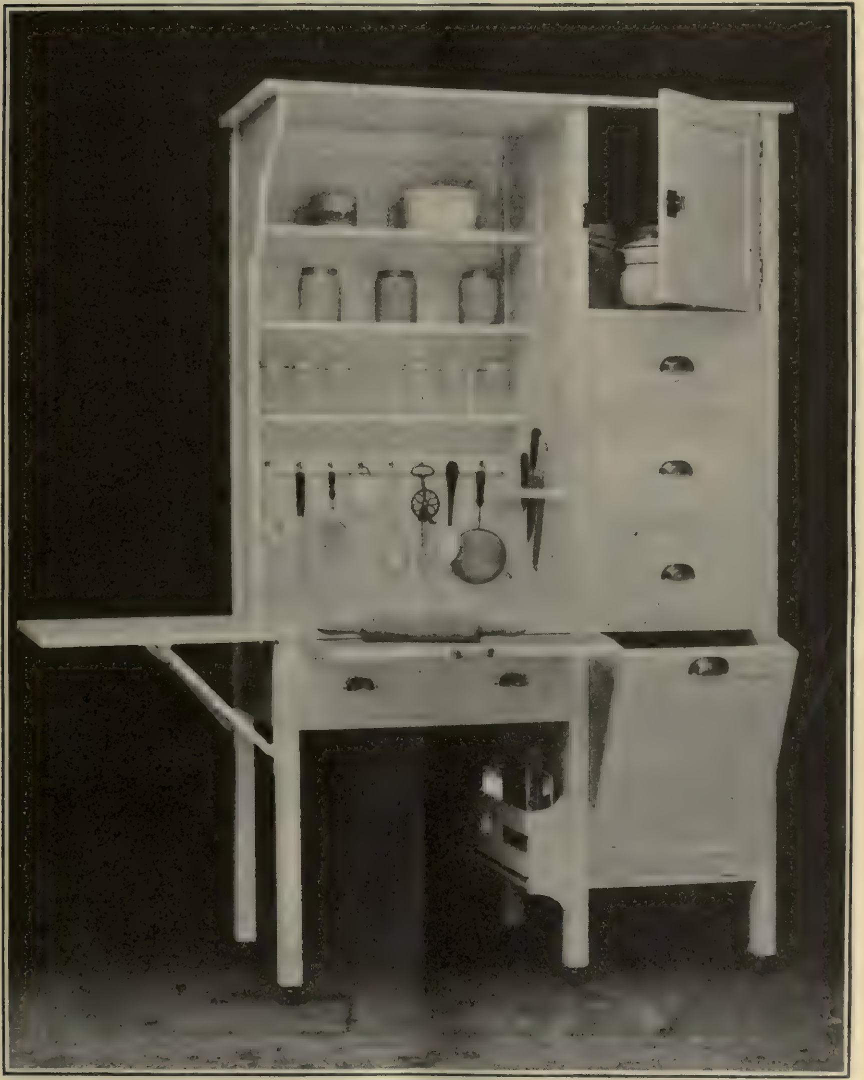

FIG. 1.—Kitchen cabinet.

DIRECTIONS FOR MAKING FIRELESS COOKER.

A tightly built box, an old trunk, a galvanized-iron ash can, a candy bucket, a tin lard can, a lard tub, and a butter firkin are among the containers that have been used successfully in the construction of fireless cookers. (Figs. 2 and 3).

The inside container or nest which holds the vessel of hot food may be a bucket of agate, galvanized iron, or tin. This nest must be deep enough to hold the radiator and the vessel of food but not large enough to leave much space, as the air space will cool the food. The inside container must have a tight-fitting cover, and straight sides are desirable.

The packing or insulation must be some material which is a poor conductor of heat. The following materials may be used and they should be dry: Lint cotton, cotton-seed hulls, wool, shredded newspaper, Spanish moss, ground cork, hay, straw, and excelsior.

Sheet asbestos $\frac{1}{8}$ inch thick and heavy cardboard have proved to be the best lining for the outer container and the wrapping for the nest. Heavy wrapping paper or several sheets of newspaper may be used for lining the outer container, but the nest should be wrapped with asbestos or heavy cardboard to prevent the hot stone scorching or burning the packing.

1. It is well to have the outside container large enough to permit 4 inches of packing below and around the sides of the nest. If a

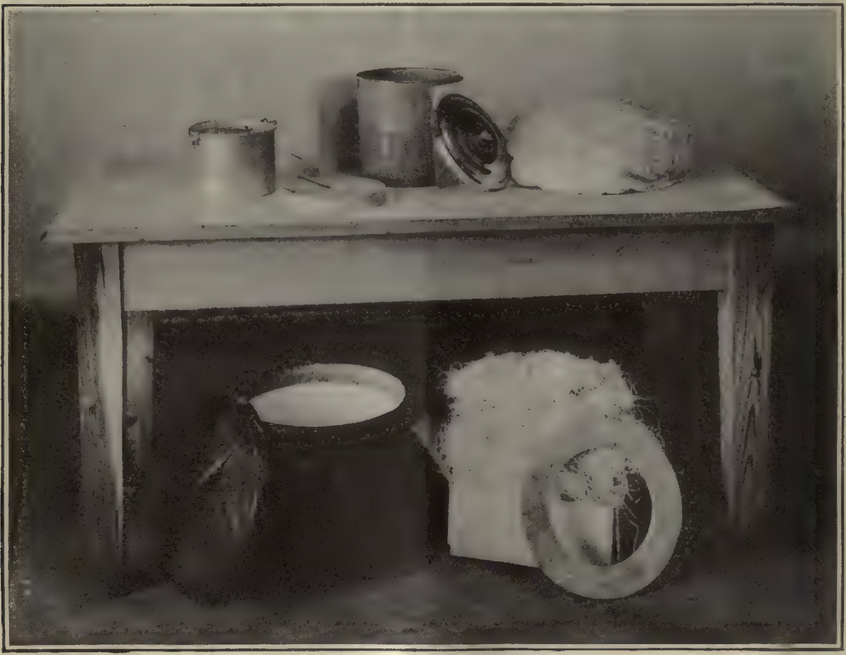

FIG. 2.—Materials assembled for making a fireless cooker.

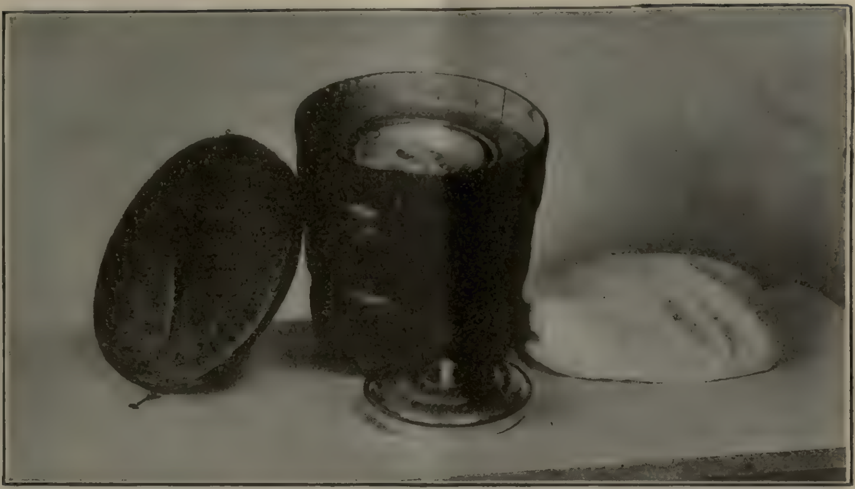

FIG. 3.—The completed fireless cooker.

cooker is being made with two nests, 6 inches of packing should be allowed between the nests. Pack into the bottom of the lined outer container 4 inches of the packing. Place the nest or inside container wrapped with asbestos or heavy cardboard and hold steady while the packing is put around tightly and firmly until it reaches the top of the nest.

2. Make a collar, as shown in illustration, of cardboard, sheet asbestos, or wood to cover the exposed surface of the insulating material. This collar should fit tightly.

3. Make a cushion which when filled with the packing will be at least 4 inches thick and will fill completely the space between the top of the nest and the lid of the outside container. It should fit against the top tightly enough to cause pressure when the lid is closed.

4. The outside of the fireless cooker can be made more attractive by staining or painting it. The lid may be held in place by screen-door hooks and eyes. The cooker may be placed on casters so that it can be easily moved.

Selected recipes for preparing food to be cooked in the fireless cooker may be found in Farmers' Bulletin 771, Homemade Fireless Cookers and Their Use.

SPONGE BOX OR BREAD RAISER.

In making bread the housekeeper often finds it difficult to hold her sponge or dough at the right temperature so that it will rise in a shorter period of time. She will find a sponge box or bread raiser (fig. 4) a great help in keeping the proper temperature. Such a box can be made from an ordinary dry-goods packing box.

A box 26 by 20 by 20 inches is a convenient size. About 10 inches from the bottom of the box a shelf made of slats or strips of wood rests on cleats fastened to the sides of the box. A second shelf is placed 4 inches above the lower one. The shelves can be removed when cleaning the box. Below the lower shelf a sheet of galvanized iron slightly wider than the shelf is inserted. It is curved in order to make it slip in and stay in place securely. This prevents scorching of the lower shelf when a lamp is placed below and also helps to distribute the heat more evenly. The door is hinged and fastened with a thumb-latch or hook and staple.

Several small holes are bored in the lower and upper parts of the sides and in the top of the box to promote circulation of air. A cork which has been bored through the center to admit a straight thermometer is inserted in one of the holes in the top of the box. A Fahrenheit chemical thermometer that registers as high as 100° can be used. Such a thermometer may be ordered through a hardware dealer or directly from an instrument dealer.

To avoid all danger of fire, the box should be lined with asbestos or tin when a kerosene lamp is used for heating the box. If an electric light is used, the lining is not necessary. A 16-candlepower light will heat the box nicely. A small and inexpensive night lamp is placed in the bottom of the box and a shallow pan of water is placed on the lower shelf so that the air in the box will be kept moist.

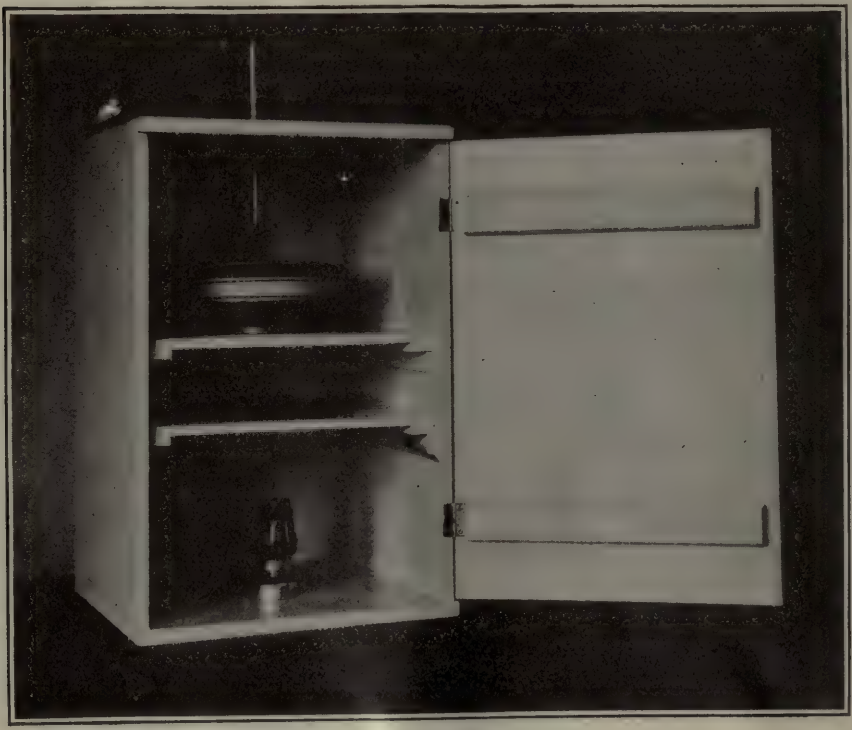

FIG. 4.—Sponge box.

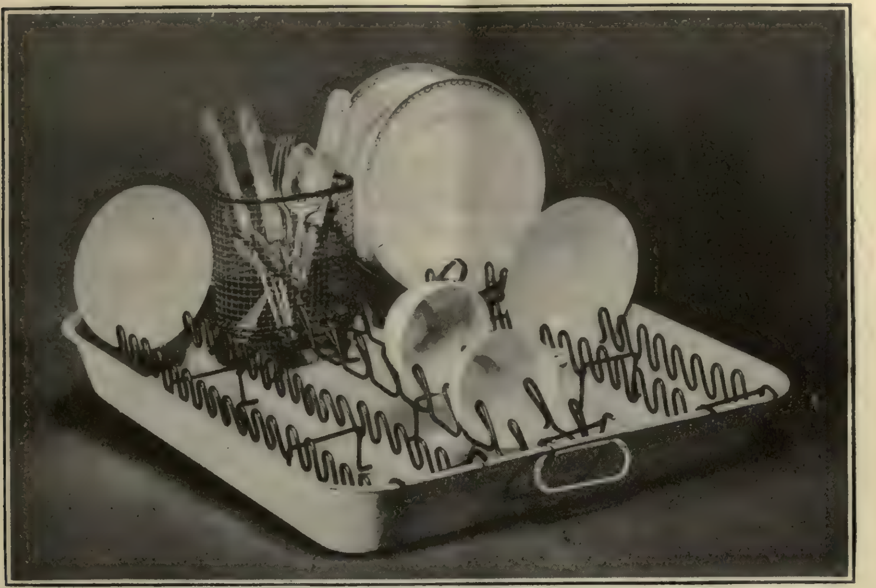

FIG. 5.—Dish drainer.

The bowl of sponge or pans of dough are placed on the upper shelf. The temperature of the box should be kept as near 86° F. as possible (80° to 88° F.) when bread is being made in the quick way. If a sponge is set overnight 65° to 70° F. is the better temperature until the dough is made in the morning, after which the temperature may be increased to 86° F. The temperature in the box may be varied by raising or lowering the flame of the lamp or by using warm or cold water in the shallow pan.

DISH DRAINER.

Perhaps no time spent in housework is more begrudged by the housekeeper than that spent in washing and wiping dishes. A dish drainer not only saves time and labor but it does away with the too often insanitary dish towel.

A most satisfactory dish drainer, as shown in figure 5, can be made by using an ordinary bread or biscuit pan and racks made of soft No. 12 or 14 wire. By using a pair of pliers the wire can be bent into the proper shape for forming the racks. The racks fit into the pan and hold the dishes out of the water. The compartment for silver is made of poultry netting. This compartment could be made of screen wire or a tin can with holes in the bottom might be used.

After the dishes are washed they are stacked in the racks and scalded with hot rinsing water. The pan catches the drip, and the dishes upon standing dry clean and lintless. If the drainer is used on the drain board of a sink a small hole can be made in the pan and the drip drained immediately into the sink. The wire racks can easily be removed so that the pan can be used for other purposes.

HEIGHTS OF WORKING SURFACES.

Kitchen tables and the bottom of sinks are usually too low for working surfaces when the housekeeper is standing. Low working surfaces are often responsible for tired backs and rounded shoulders because of the undue stooping and the strain on the arms and shoulders. The following figures show the proper level of working surfaces for the height of the housekeeper:

Height of woman.	Proper height of working surface. Inches.
4 feet 10 inches	27
5 feet	28
5 feet 2 inches	29
5 feet 4 inches	30
5 feet 6 inches	31

The kitchen table can be raised to the proper height by the use of blocks of wood. Different types of blocks for raising the height of tables are shown in figure 6.

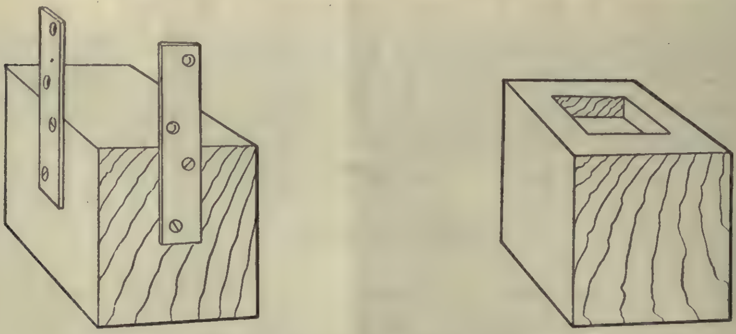

FIG. 6.—Blocks for raising tables.

(*a*) A block of wood with a socket in which the table leg fits securely.

(*b*) A block of wood with metal strips and screws or nails for fastening the table legs or the cabinet table.

SERVING TRAY.

The serving tray (fig. 7) is a strength and time saver. The tray saves many trips between the dining room and kitchen, both in serving and in clearing away meals, especially in a large household where many dishes must be handled. The top and shelf spaces are sufficient to remove all dishes to or from the table in one trip. It saves steps in serving refreshments at social occasions. It is invaluable to use as a bedside tray in the sick room. The tray when made well is attractive as well as useful and may serve as a reading table or flower stand. (Fig. 8.)

The upper part of the serving tray is box shaped, 16 inches wide and 26 inches long. This is supported by four legs 1⅝ by 1⅝ inches, which measure 31 inches from the floor to the top of the tray. The top of the tray or the lid of the china compartment is edged by a

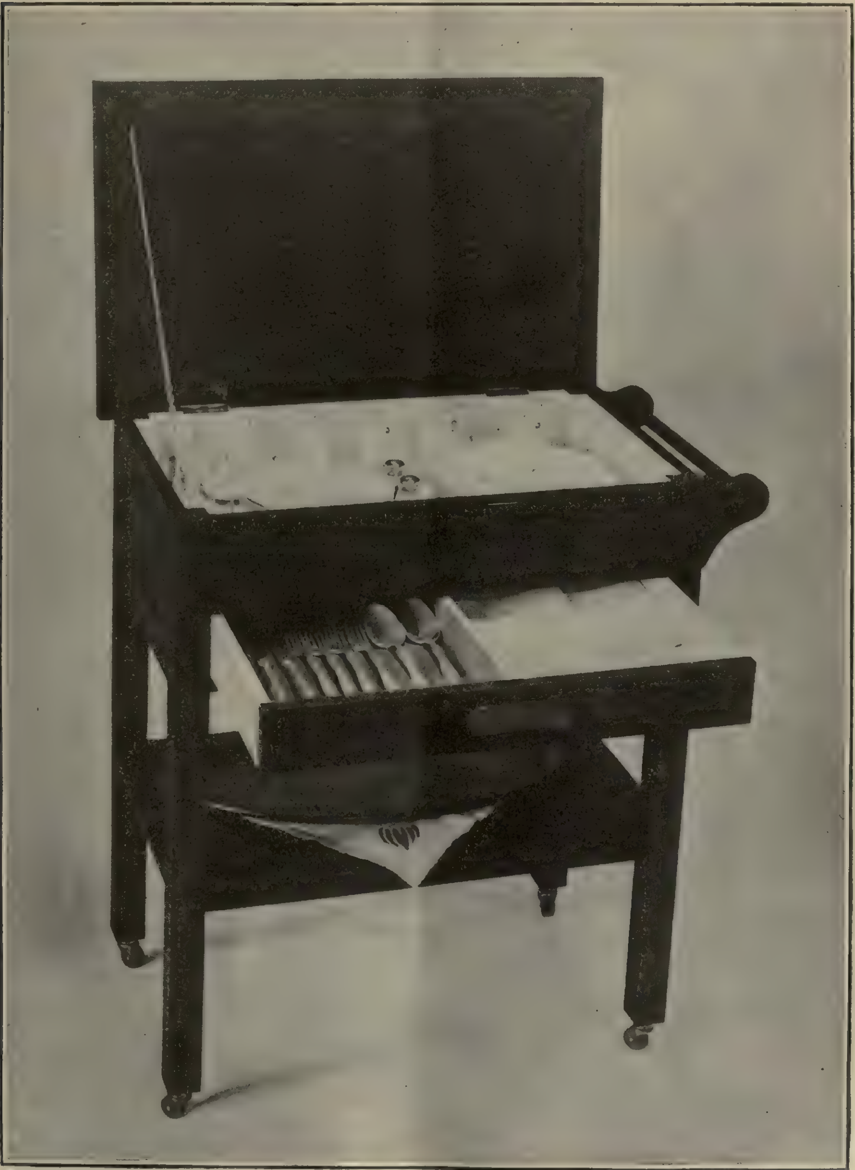

Fig. 7.—Serving tray, opened.

1¼-inch molding. The china compartment is 4½ inches deep and is painted white within. On the sides of this compartment are little screw hooks on which cups may be hung. There is space in the compartment for serving dishes for six.

Below this serving compartment is a drawer 2 inches deep, which is divided into two parts. One side is used for linen and one side for silver. The side used for silver is lined with dark-colored felt or outing flannel.

In the space below the drawer a large undershelf is placed. The serving tray is put on noiseless swivel castors, thus allowing the table to turn completely around, which is a great convenience. Instead of castors, small swivel wheels or the small wheels of a baby carriage or toy wagon may be used. A tray made by the dimensions given above is a convenient size and one that will go through doorways without danger of bumping.

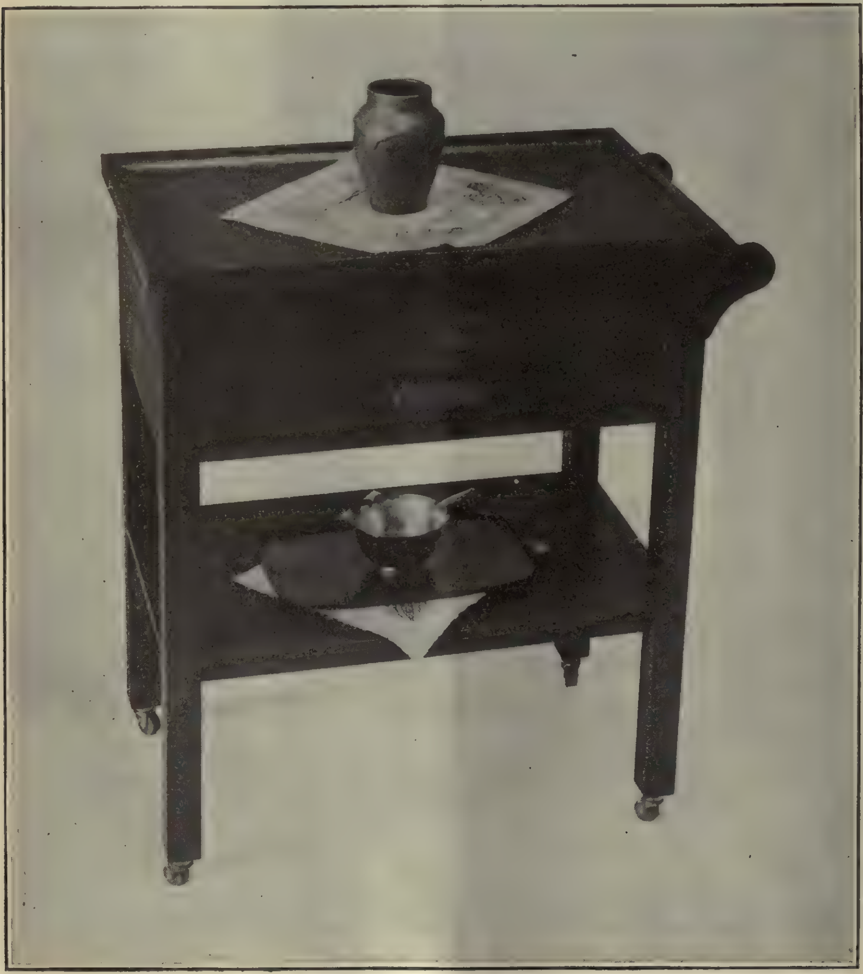

FIG. 8.—Serving tray, closed.

FOLDING IRONING BOARD.

The ironing board shown in figure 9 can be fastened up against the wall and is out of the way when not in use. It should be made of well-seasoned 1 or 1¼ inch material. A board of convenient size can be made by the following dimensions: 4 feet 8 inches long, 15 inches wide at the attached end, and 8 inches at the free end. About 2 feet from the attached end the board begins to taper gradually. The free end is rounded.

A strip 1¼ by 4 by 15 inches is securely fastened by screws to the wall at a convenient height. The height at which the board is placed varies with the height of the user. For a woman of average height it should be 31 or 32 inches. The board is hinged to the wall strip with two No. 3 butt hinges. (Fig. 9.)

The leg or brace, made of material 1 inch thick and 4 inches wide, is fastened with a No. 3 butt hinge to a board strip 1 by 4 by 8 inches. The board strip is screwed to the underside of the board 11 inches from the free end. The length of the brace depends upon the height of the board, and when the board is in position the brace rests against the baseboard of the wall. Skirts may be easily ironed without changing the position of the brace. A piece of galvanized iron may be tacked to the board, on which the hot iron may rest when not being used. The board is folded up against the wall and may be held in place by using the upper part of the rack for holding the portable ironing board. This rack is shown in figure 10.

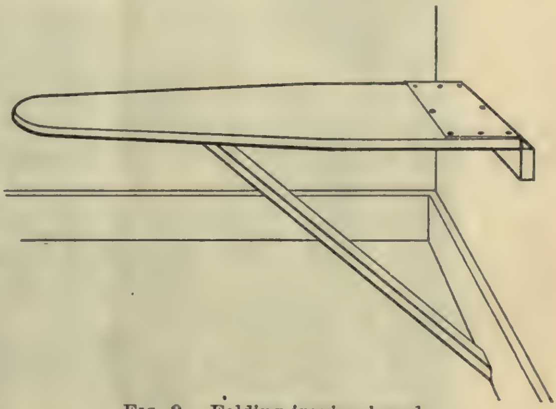

FIG. 9.—Folding ironing board.

RACK FOR PORTABLE IRONING BOARD.[1]

The ironing-board rack or holder (fig. 10) may be attached to the wall or to the inside of a closet door to hold a portable ironing board when not in use. The upper part of the holder is made of 2½-inch material and is 5 inches in depth. It is 12 inches across the top and is shaped to fit the contour of the smaller end of the ironing board. In the center is a button which holds the top of the board in place. The button is made of metal and so shaped as to give it

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[1] Designed by Mr. Paul H. Lipp, Bureau of Plant Industry, U. S. Department of Agriculture.

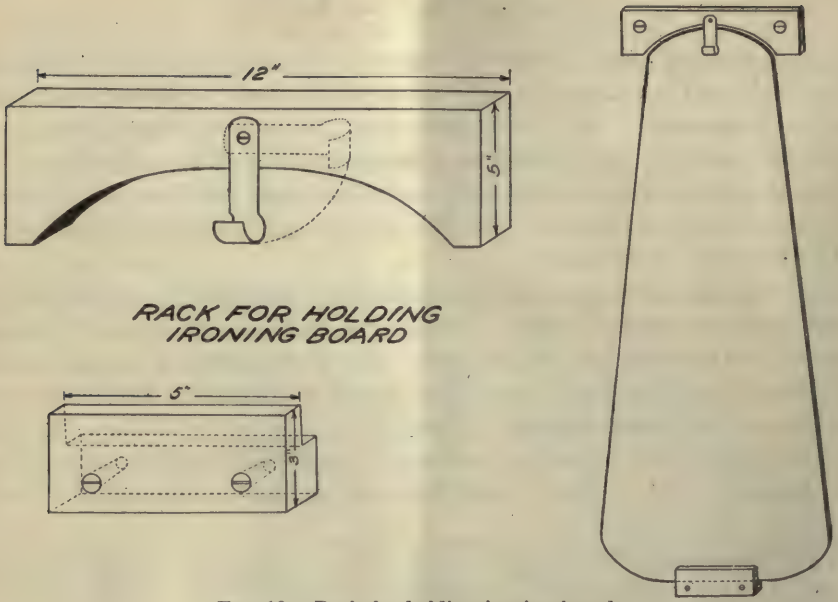

FIG. 10.—Rack for holding ironing board.

a spring and to provide a finger hold for easy movement. The upper part of the rack or holder is screwed to the wall or door.

The bottom or lower part of the rack is 5 inches wide and 3 inches in depth, and is made of 2½-inch material. It is rabbeted on the side next to the wall. An inch rabbet is cut in to form a rest for the ironing board. This part of the rack is fastened with two screws to the wall or door.

THE ICELESS REFRIGERATOR.[1]

A very useful convenience for the farm home, where ice is not obtainable, is the iceless refrigerator (figs. 11 and 12). It will keep meats, fruits, and vegetables cool, and will extend the period for keeping milk and butter. It can also serve as a cooler for drinking water. In homes where large quantities of milk and butter are to be kept, it would be well to have one refrigerator for milk and butter, and another for other foods, as milk and butter readily absorb odors from other foods. It costs very little to build the refrigerator and nothing to operate it.

CONSTRUCTION.

A wooden frame is made with dimensions 42 by 16 by 14 inches and covered with screen wire, preferably the rustless type, which costs little more than the ordinary kind. The door is made to fit closely and is mounted on brass hinges, and can be fastened with a wooden latch. The bottom is fitted solid, but the top should be covered with screen wire. Adjustable shelves can be made of solid wood or strips, or sheets of galvanized metal. Shelves made of poultry netting on light wooden frames, as shown in the illustration, are probably the most desirable. These shelves rest on side braces placed at desired intervals. A bread baking pan, 14 by 16 inches, is placed on the top and the frame rests in a 17 by 18 inch pan.

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[1] The original model from which this iceless refrigerator has been adapted was made by Mr. Thomas Fullan, Alabama Polytechnic Institute, Auburn, Ala.

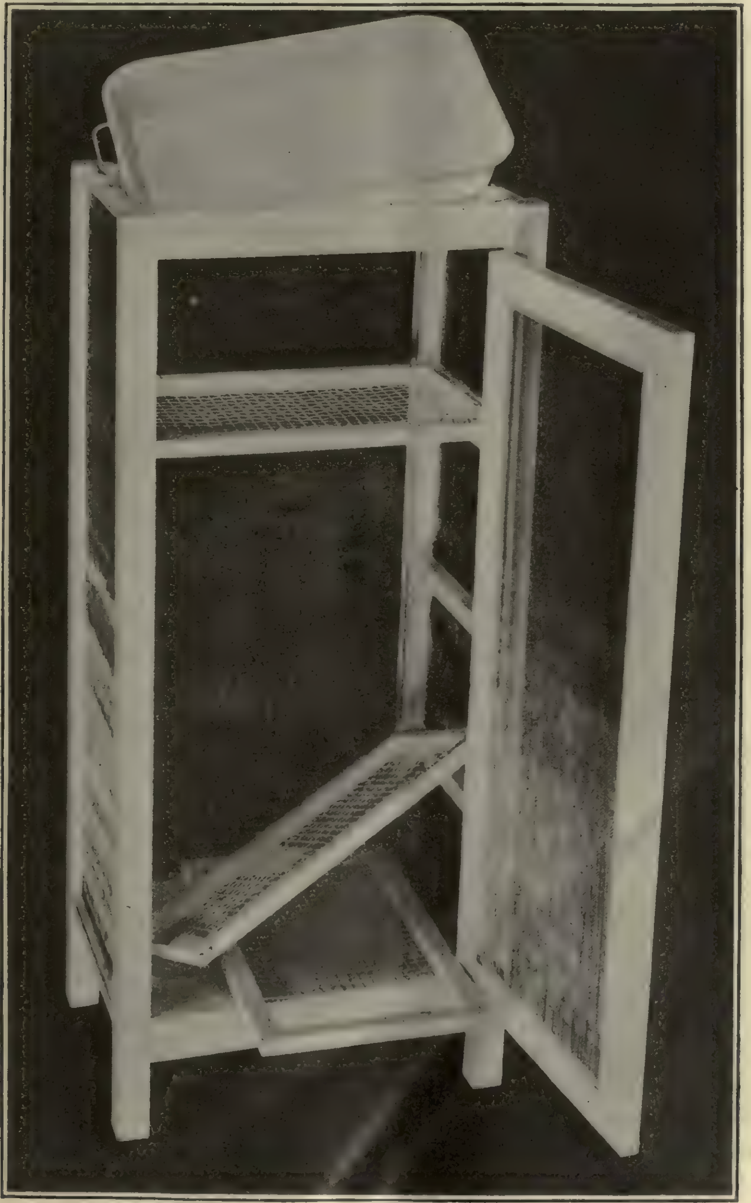

FIG. 11.—Framework of the iceless refrigerator.

All the woodwork, the shelves, and the pans should receive two coats of white paint and one or two coats of white enamel. This makes a very attractive surface and one that can be easily kept clean. The screen wire also may receive the coats of enamel, which will prevent it from rusting.

A cover of canton flannel, burlap, or duck is made to fit the frame. Put the smooth side out if canton flannel is used. It will require about three yards of material. This cover is buttoned around the top of the frame and down the side on which the door is not hinged, using buggy hooks and eyes or large-headed tacks and eyelets worked in the material. On the front side arrange the hooks on the top of the door instead of on the frame and also fasten the cover down the latch side of the door, allowing a wide hem of the material to overlap the place where the door closes. The door can then be opened without unbuttoning the cover. The bottom of the cover should extend down into the lower pan. Four double strips, which taper to 8 or 10 inches in width, are sewed to the upper part of the cover. These strips form wicks that dip over into the upper pan.

The dimensions given make a refrigerator of very convenient size for household use and one with efficient evaporating surface, but it is not necessary to follow strictly these dimensions. If a larger capacity is desired, the height of the refrigerator can be increased.

OPERATION.

The operation of the refrigerator shown in the illustrations is as simple as its construction. The lowering of the temperature of the inside of the refrigerator depends upon the evaporation of water. To change water from a liquid to a vapor, or to bring about evaporation, requires heat. As evaporation takes place heat is taken from the inside of the refrigerator, thereby lowering the temperature of the inside and the contents.

Keep the upper pan filled with water. The water is drawn by capillary attraction through the wicks and saturates the cover. Capillary action starts more readily if the cover is first dampened by dipping it into water or throwing water upon it with the hand. The greater the rate of evaporation the lower the temperature which can be secured; therefore the refrigerator works best when rapid evaporation takes place. When the refrigerator is placed in a shady place in a strong breeze and the air is warm and dry, evaporation takes place continuously and rapidly and the temperature inside the refrigerator is reduced. Under ideal conditons the temperature has been known to be reduced to 50° F. When it is damp, and the air is full of moisture, the refrigerator will not work as well, since there is not enough evaporation. More water will find its way to the lower pan, but it will be drawn up into the covering by capillary attraction when the air again becomes drier.

CARE OF REFRIGERATOR.

The refrigerator should be regularly cleaned and sunned. If the framework, shelves, and pans are white enameled they can more easily be kept in a sanitary condition. It is well to have two covers, so that a fresh one can be used each week and the soiled one washed and sunned.

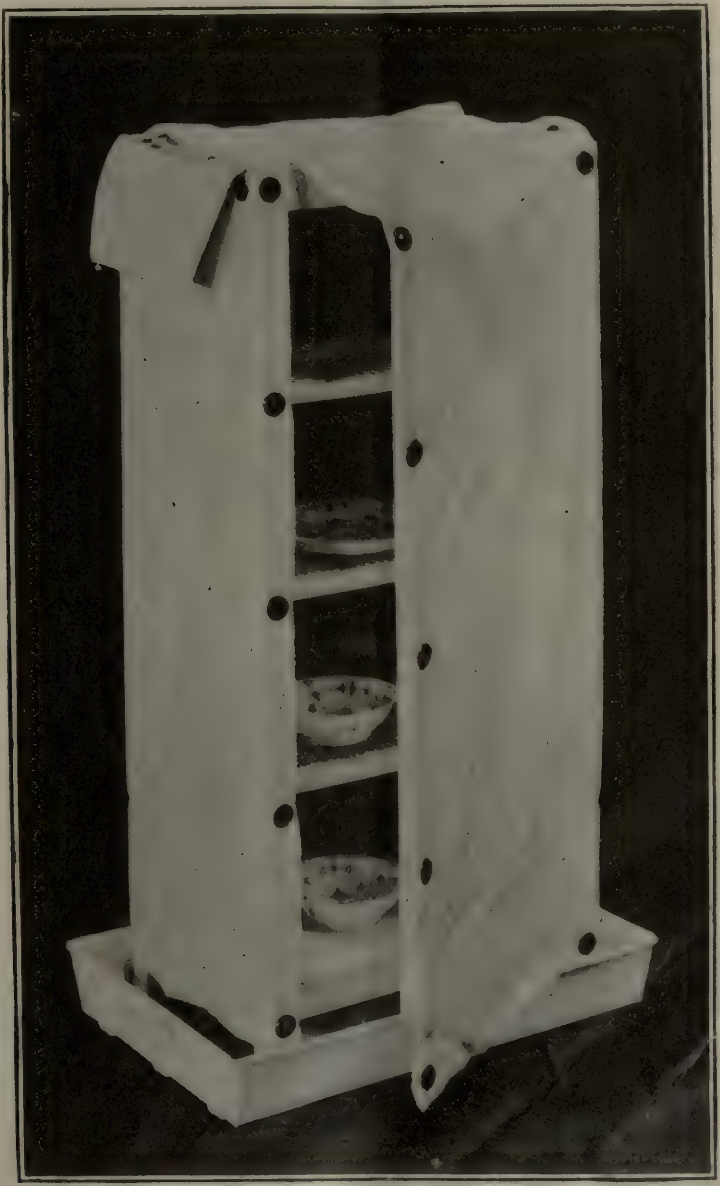

FIG. 12.—The completed iceless refrigerator.

THE COLD BOX.

For keeping food during cool weather a cold box will be found very satisfactory. An ordinary light box can be used or one can be easily and cheaply made for the purpose. The box is fitted to the outside of the kitchen or pantry window. The north exposure is the coolest location. Raising the window gives access to the cold box. By this arrangement the light from the upper half of the window is still available. (Fig. 13.)

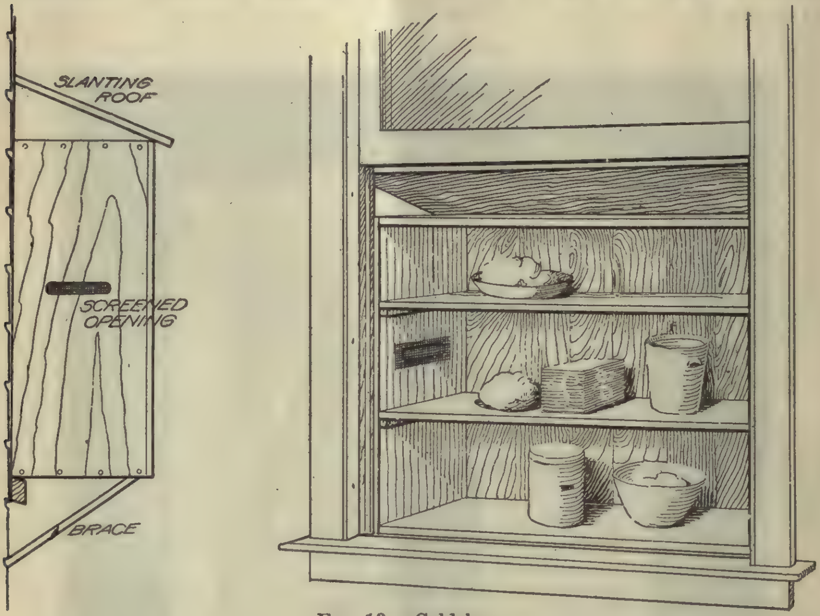

FIG. 13.—Cold box.

The window sill is extended by a shelf which is supported by wooden brackets. The cold box rests on the window sill and the extended shelf, and is fastened to the window casing by screws or nails near the top and bottom of each end of the box. During warm weather, when the box is not in use, it may be removed if desired. The box should have a sloping top to shed the rain. Holes for ventilation are made in the ends of the box and screened. Shelves in the box may be made of heavy screening or poultry netting or of wood. They rest on cleats fastened to the sides of the box.

Food placed in the box should be covered so as to protect it from dust.

EQUIPMENT FOR HOME BUTTER MAKING.

There is no secret in making good butter. With proper care and attention to details good butter can be made in any farm home. The quality of the butter is dependent upon the intelligent use of equipment rather than the kind, although suitable equipment is time-saving and labor-saving and can be purchased and made at a nominal cost. (Fig. 14.)

Milk vessels should be of high-grade tin with all joints and seams smoothly soldered so that there will be no crevices in which dirt may accumulate. A convenient milk can to use is the 3-gallon shotgun can. It should have a smooth, heavily tinned interior, to prevent rusting and difficulty in cleaning. All butter-making equipment should be thoroughly scrubbed with a brush in hot water containing sal-soda or washing powders. Never use a dish cloth or soap. Inexpensive stiff fiber scrub brushes or vegetable brushes can be purchased at any grocery or hardware store. After equipment is washed it should be scalded or steamed. A homemade sterilizer will be found most convenient and helpful. (See Farmers' Bulletin 748.)

A medium-sized dipper strainer with a fine-meshed gauze has been found to be very satisfactory. It should be smooth and free from seams. Butter should not be touched or handled with the bare hands. It injures the quality of the butter and is very insanitary. Wooden ladles can be easily whittled from maple, ash, or poplar or brought at a small cost. A thermometer is absolutely essential to successful butter making. Controlling temperatures is second only to keeping equipment clean. A floating dairy thermometer can be ordered from any dairy supply company.

In making butter the salt should be uniformly distributed and the granules pressed together into a close-grained mass and the surplus water worked out. This can be most easily accomplished by use of

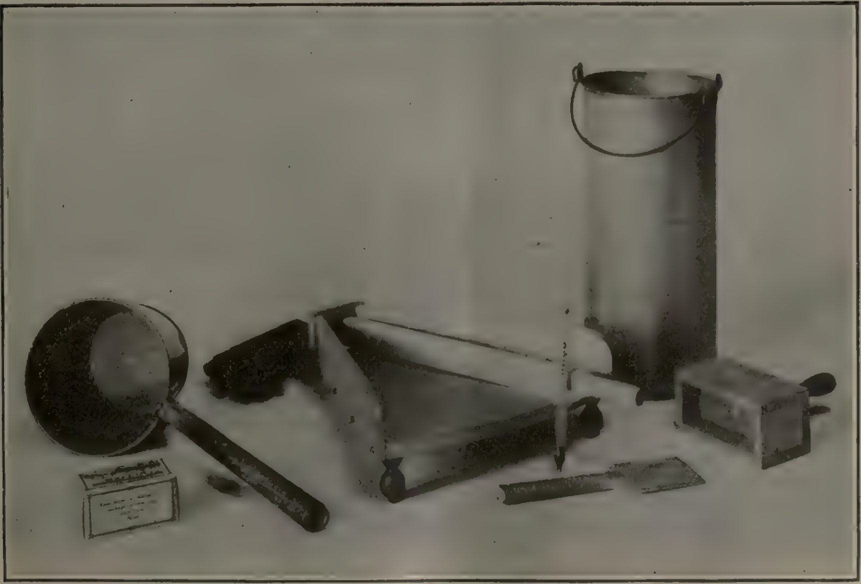

FIG. 14.—Equipment for home butter making.

a V-shaped lever butter worker made of 1-inch material. This worker is made of maple, ash, or poplar, the material of which all wooden butter equipment is made. Any woods from which odors or flavors might be absorbed by the butter should not be used.

For the amount of butter made in most farm homes a butter worker 18 inches long, 16 inches at the wide end and 2½ inches at the narrow end is a convenient size. The sides are 3 inches wide and are screwed to the bottom. The corrugated roller having six or eight sides is 24 inches long. One end of the roller is shaped to fit a small hole made in the piece across the narrow end of the worker. This end piece is of a width that leaves a slot just above the bottom of the worker which allows the water to drain off into a pan as the roller is pressed firmly backward and forward over the butter. The worker rests on three knobs or supports. The two knobs at the wider end are 3½ inches high, while the knob at the narrow end is 2½ inches. (Fig. 14.)

The most popular, convenient, and attractive butter mold is the brick-shaped or square-cornered mold. This mold can be made of ⅝-inch material. The mold most commonly used is 4⅝ by 2½ by 2⅜ inches. An inch hole is bored through the center of the top and through the center of a plunger which fits closely into the mold. Through the hole in the top of the mold is inserted the round handle which screws into the hole in the plunger. Most satisfactory molds of this type can be found on the market.

When butter is to be sold, parchment papers 8 by 11 inches should always be used to wrap the pound print. Also neat and attractive

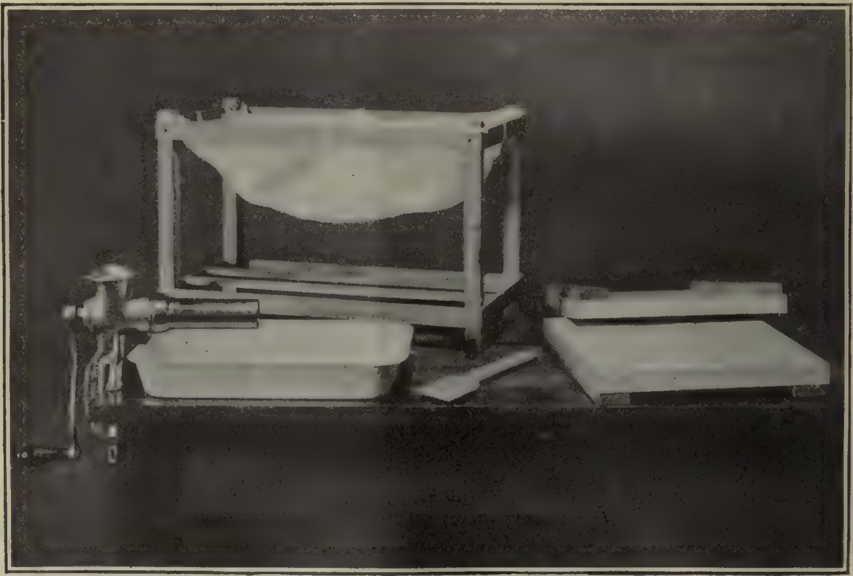

FIG. 15.—Cheese-making equipment.

paper butter cartons should be used when butter is put on the market. It will bring a better price if packed well.

To make the butter-making equipment complete, a barrel churn should be added. The barrel churn is generally recognized as the most convenient and efficient kind of churn in use. When an extra large quantity of milk is handled it pays to use a cream separator. A separator insures more and better butter.

CHEESE-MAKING EQUIPMENT.

Cottage, Neufchatel, plain cream, and pimiento cream cheese can be made in the farm home where a surplus supply of milk is available. Cheese is not only a very valuable food in the family diet, but if a first-class product is produced a good market can usually be found for it. The equipment for making cheese is very simple and most of it could be made at home.

The rack for draining the cheese is 16 inches deep, 12 inches wide, and 24 inches long, and is made of pine. The bottom slats which hold the pan under the draining cloth fit into notches made in the lower side strips and can easily be removed when the rack is washed. The corner posts extend ¾ inch above the strips at the top and the corner loops of the muslin or cheesecloth drain cloth are looped over the posts. A similar rack, as described, could be made out of an orange or vegetable crate. (Fig. 15.)

The press is made of two poplar or maple boards 1¼ inches thick and 14½ inches square. Strips of wood 1¾ inches wide are nailed or screwed on the back of each board to prevent them from warping. The boards are planed and sandpapered until perfectly smooth. The lower board has a circular groove which has an outlet through which the whey drains as it is pressed out of the curd.

A wooden paddle, a dairy thermometer, and a food chopper or sausage grinder with molding tube complete the necessary equipment. The molding tube or cylinder could be made by a tinsmith or can be ordered through a hardware dealer. The paddle can easily be made. The molding tube or stuffing attachment which is attached to the food chopper molds the Neufchatel and cream cheese into attractive and convenient molds for the market. The cheese can also be packed into small glass jars by placing the opening of the jar over the end of the tube through which the cheese is forced. The pimiento cream cheese is always put on the market in small glass jars.

THE SHOWER BATH.

Better bathing facilities are often needed in homes where bathrooms are not found. A cheap and convenient shower bath can be easily made and used in the kitchen or on the back porch. (Fig. 16.)

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Usage

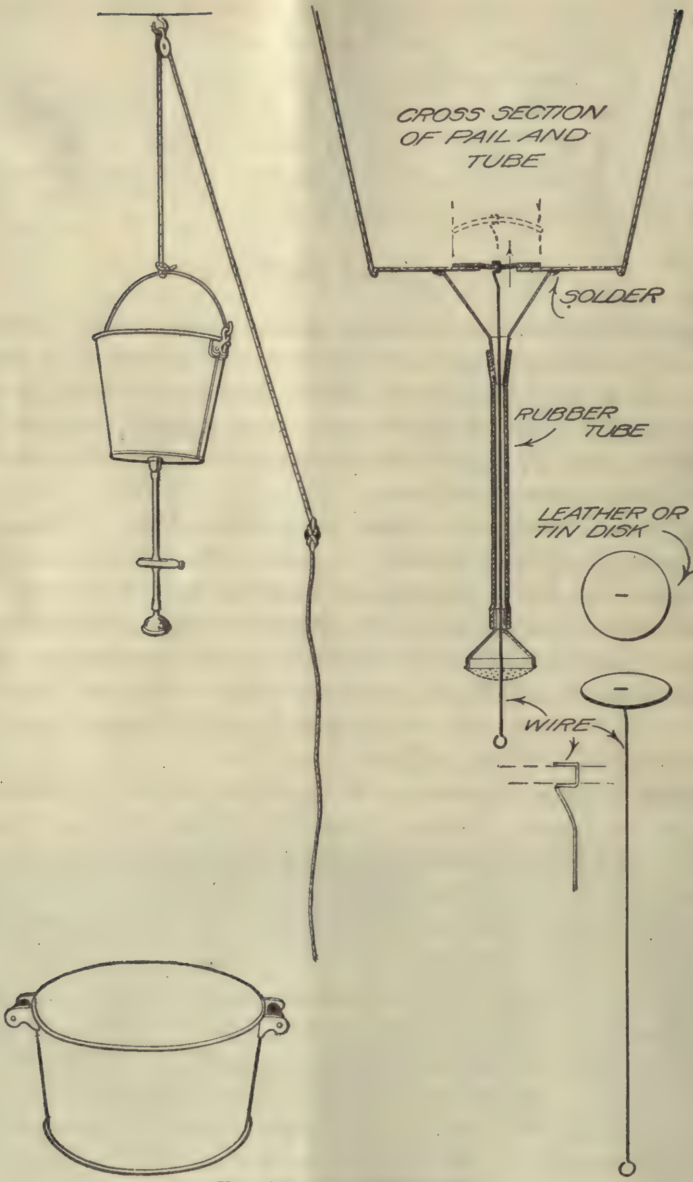

FIG. 16.—The shower bath.

The shower bath is especially useful in homes where there are children.

A hole is cut in the bottom of a 4-gallon bucket and a piece of pipe 2 inches long soldered in the opening. Rubber tubing 4 to 6 feet long is attached to the pipe and a nozzle is fitted on the end of the rubber tubing. A sprinkler from a watering can may be used instead of the nozzle. The bucket can be raised or lowered to suit the convenience of the person taking the bath by a rope fastened to the handle of the bucket and run through a pulley which is fastened with a staple to a joist in the ceiling. The end of the rope is looped over a hook, which is driven securely into the window or door facing, or into the studding in the wall.

A clothespin closed over the rubber tubing serves as a stopcock to cut off the water as desired. The shower can be better regulated by using a device such as is shown in the illustration. The end of a piece of No. 12 or 14 wire is fastened to a disk of leather or tin, or a cap of a tin can, by making a hole in the material used, running the wire through and looping the end. This disk is placed over the hole in the bottom of the bucket and the attached wire extends through the rubber tubing and the nozzle. The shower can be regulated by the disk being raised and lowered by means of the wire. The weight of the water in the bucket on the disk will form a sufficient seal when no flow is desired.

A large tub is placed under the shower, in which the bather stands. The tub and bucket are more attractive if given two coats of white paint and one coat of white enamel.

WELL PROTECTION AND INEXPENSIVE WATERWORKS FOR A FARM KITCHEN.[1]

The three important principles to consider in the subject of water supply for the farm home are: (1) It is necessary to have clean water, (2) there should be convenient and serviceable equipment to furnish running water in the house, and (3) this convenient supply of safe water should be secured with economy.

The first and most important consideration is to get a supply of clean water. By clean water is meant water which is both clear and pure. Good farm water supplies are usually obtained from wells, springs, and cisterns. Water from wells on farms is frequently contaminated and contains the source of disease. Contaminated water may be the cause of outbreaks of typhoid fever, dysentery, and other intestinal disorders among members of the family.

Both shallow dug wells and deep bored wells may be polluted by the entrance of filth, vermin, and unclean water at the top and also by seepage of contaminated soil water. These are the results of poor location of the well, generally unclean surroundings, open or loose well curbs, the absence of a well lining, or the presence of a poor well lining. The first step in securing a clean water supply is to remove all sources of possible contamination. Among the worst of these are the open privy vault, the leaching cesspool, and barnyard filth. A well in ordinary pervious soil, located lower than and within 100 feet of any of these, is almost certain to be contaminated.

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[1] Information and plans furnished by Mr. R. W. Trullinger, States Relations Service, United States Department of Agriculture.

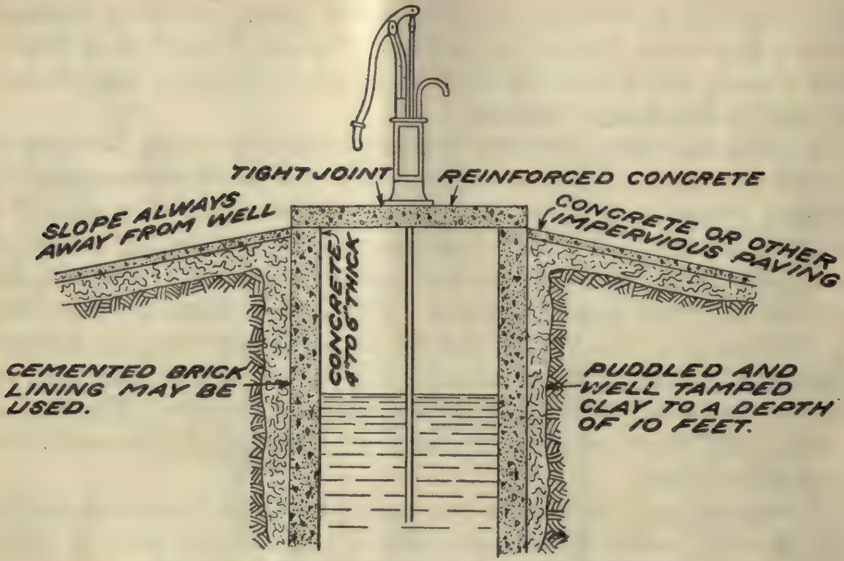
TIGHT JOINT
REINFORCED CONCRETE
SLOPE ALWAYS AWAY FROM WELL
CONCRETE OR OTHER IMPERVIOUS PAVING
CONCRETE 4" TO 6" THICK
CEMENTED BRICK LINING MAY BE USED.
PUDDLED AND WELL TAMPED CLAY TO A DEPTH OF 10 FEET.

FIG. 17.—Dug well, concrete or cemented-brick lining.

The well itself should be located as high as possible with regard to buildings, stock pens, and chicken yards, and as far away from all sources of contamination as convenience and local surroundings will permit. The final safeguards to a well-water supply are to provide an impervious lining of concrete, cemented bricks, cemented tile, or iron casing, and to provide a water-tight curb, not only to keep out surface wash, animals, and vermin, but to prevent the pump drip and dirt from shoes and buckets from entering the well. (Figs. 17, 18, 19, 20.)

The same precautions with reference to the entrance of filth and polluted water from the surface apply to underground cisterns.

Springs are subject to contamination from the same sources as wells, although more often contaminated by surface wash and because animals have access to them. They can be protected by fencing in from animals, walling in the spring to form a covered and water-tight reservoir, and by keeping the surroundings clean. Spring water should be kept under close observation for any signs of surface pollution, especially those springs occurring in limestone regions.

Having secured a clean water supply, the next step is to provide equipment to furnish running water in the kitchen at the turning of a faucet or by merely pumping.

If the well or cistern is located close to the house, one of the simplest and cheapest methods of obtaining running water in the kitchen in the warmer climates is to place a covered barrel or other supply tank on a shelf outside the kitchen wall and in such a position that it can be filled from the pump through a hose, as desired. A pipe

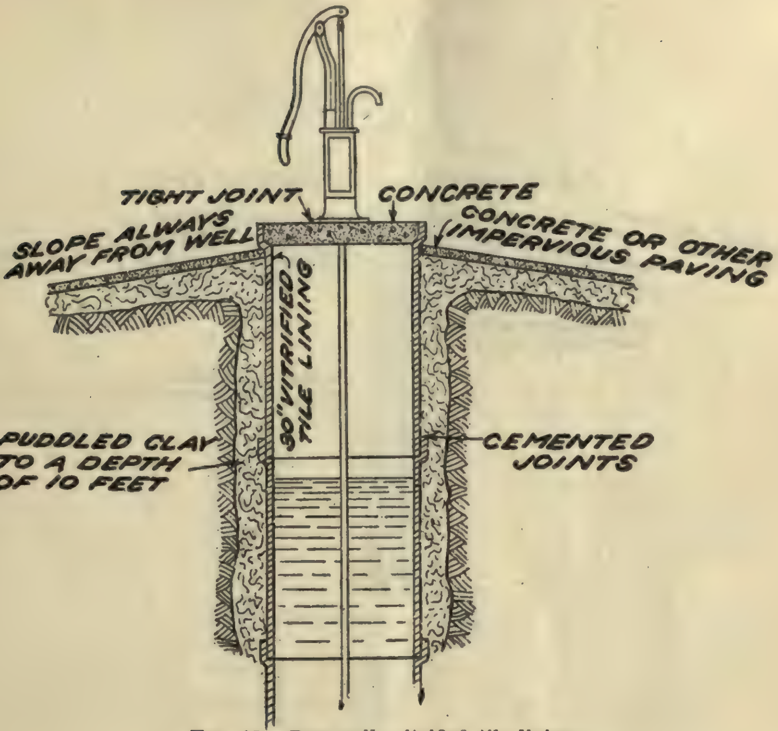
TIGHT JOINT
CONCRETE
SLOPE ALWAYS AWAY FROM WELL
CONCRETE OR OTHER IMPERVIOUS PAVING
30" VITRIFIED TILE LINING
PUDDLED CLAY TO A DEPTH OF 10 FEET
CEMENTED JOINTS

FIG. 18.—Dug well, vitrified tile lining.

attached to the bottom of the barrel or tank and passing through the wall has attached to it a faucet over a sink in the kitchen. The hose is detachable and can be removed from the pump when not in use. (Fig. 21.)

The sink is connected by lead pipe through a trap to a drain, which should consist of cast iron soil pipe when it is used anywhere in the immediate neighborhood of the well or cistern. Do not under any consideration use cemented tile for this purpose within 30 feet of any source of water supply. When far enough away from the house or well this drain can empty into open jointed drain tile which may be placed in the garden soil or any other pervious soil, thus disposing of the waste water by absorption. The disposal tile should have a fall not to exceed 1 inch in 50 feet, else the water will rush to the lower end and water-log the soil. In very porous or sand soils 1 foot of 3 or 4 inch tile per gallon of discharge per day is sufficient. In heavier loam or clay soils 2 feet of tile are necessary and sometimes more for every gallon. Aeration of heavy soil can be brought about by the use of coarse cinders or gravel laid in the bottom of the tile ditch.

Where there is danger of freezing or where the well is very close to the house, about the simplest and cheapest method is to place a pitcher pump or force pump over a sink in the kitchen. The suc-

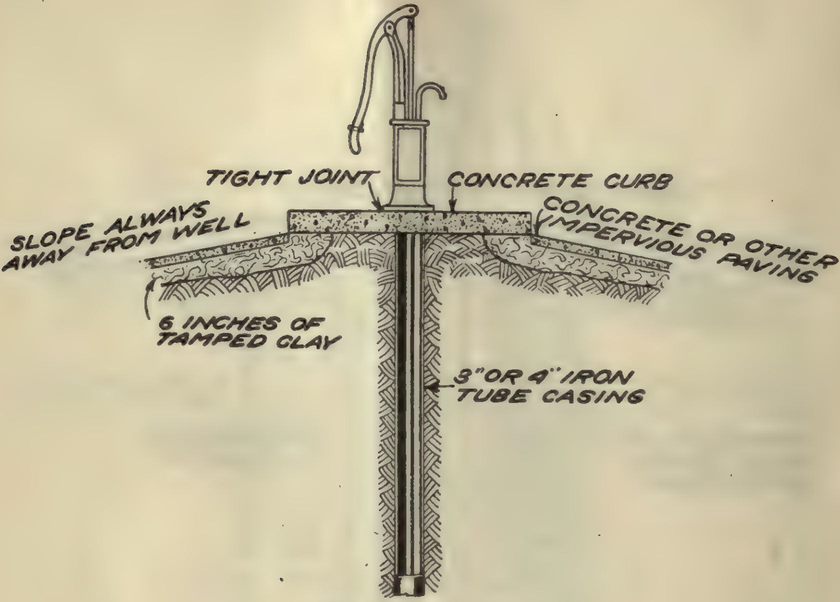
TIGHT JOINT
CONCRETE CURB
SLOPE ALWAYS AWAY FROM WELL
CONCRETE OR OTHER IMPERVIOUS PAVING
6 INCHES OF TAMPED CLAY
3" OR 4" IRON TUBE CASING

FIG. 19.—Bored well.

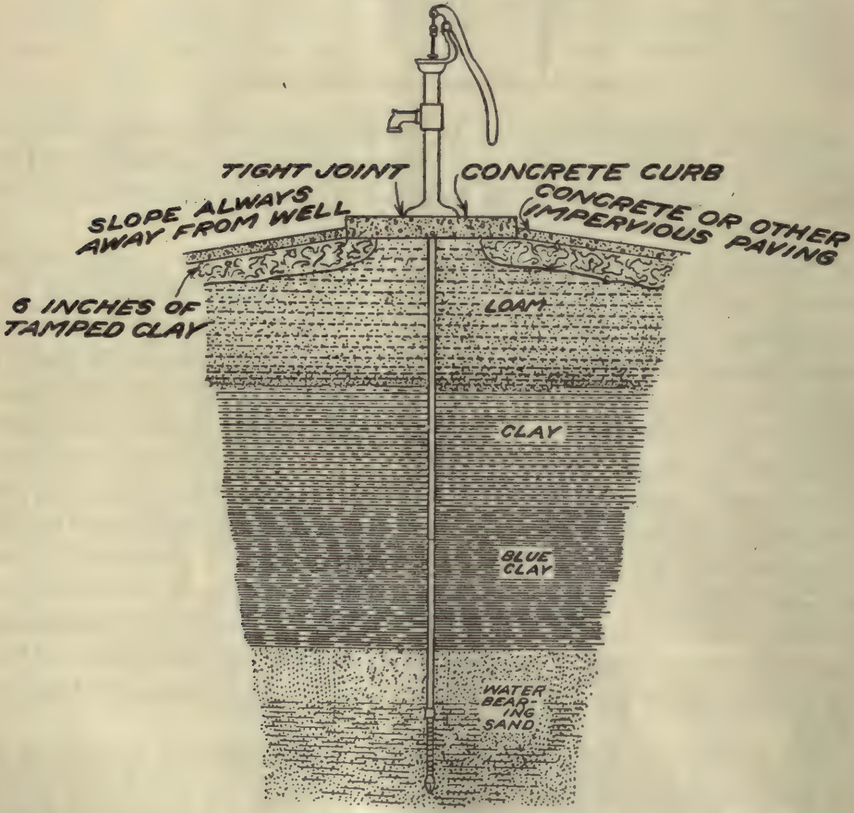

FIG. 20.—Driven well.

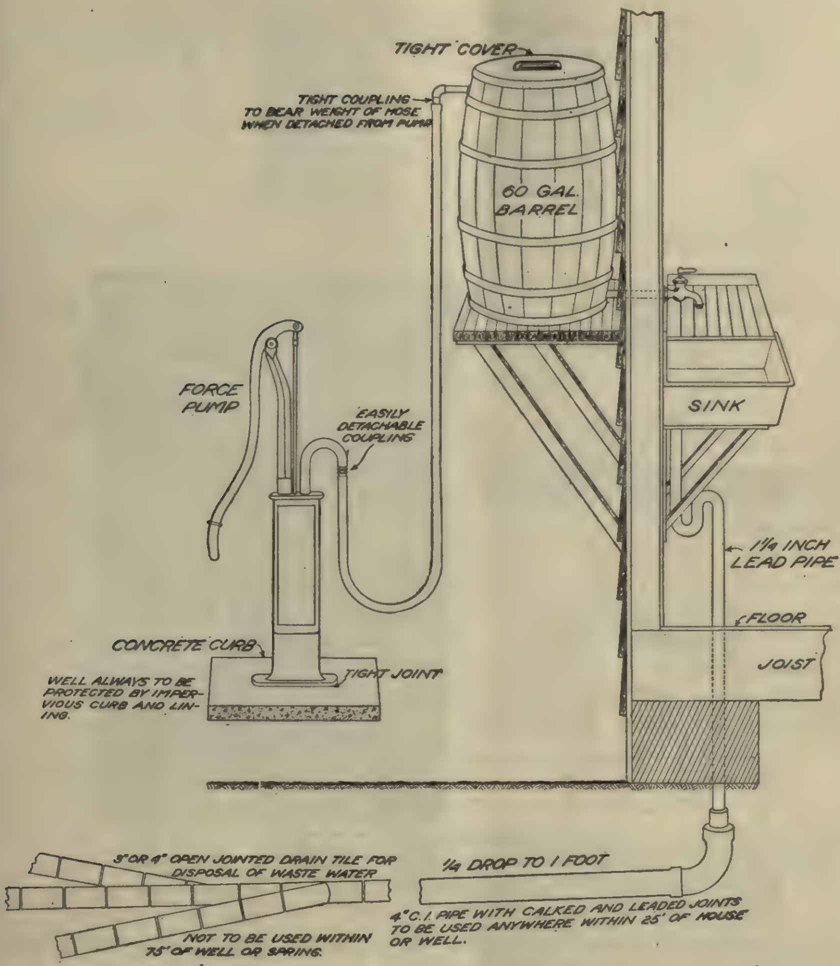

FIG. 21.—Simple water-supply system for farm kitchen.

tion pipe of the pump may be attached to the well or cistern and water obtained when desired merely by pumping. This is provided the vertical distance from the pump to the water in the well does not exceed 20 feet, as under ordinary circumstances a pump will lift water satisfactorily by suction only to about that height. The allowable distance from the well to the pump for this arrangement will vary with local conditions, cases having been noted in which the distance was as far as 200 feet. As water meets with resistance in pipes, due to friction, elbows, and bends, it is well to take off about 2 feet from the allowable vertical pumping lift for every 100 feet the water is drawn horizontally.

From the standpoint of economy, which is the third consideration, all local conditions which would have a bearing on obtaining clean water and putting it into the house with convenient and serviceable

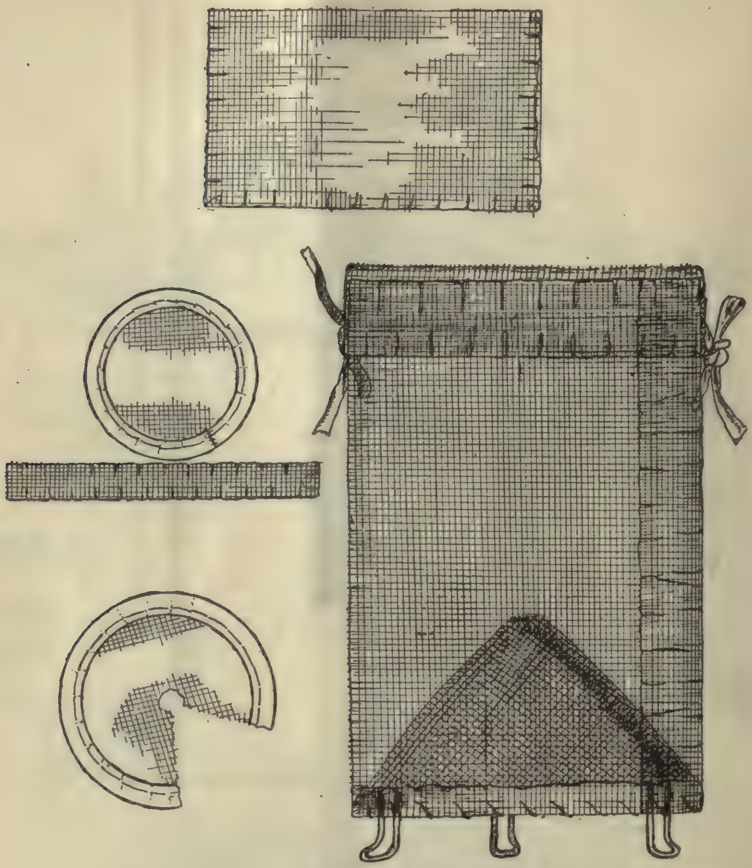

FIG. 22.—Fly trap.

equipment should be determined. No matter how cheap the system, if the water is not clean or the equipment is not serviceable or convenient, the investment is a poor one. Plan first of all to do the necessary work to give absolutely clean surroundings; next secure the proper material to protect the well. By inquiry as to local prices of material and labor the cash outlay needed can be easily determined. In the majority of cases it will be found that the well or spring can be protected by the use of material available on the farm, such as old bricks, stones, etc., with a cash outlay for little except cement, or in case of a bored well, for iron casing. The same principle should be applied in planning the water-supply equipment. All material and labor available on the farm or in the locality should first be utilized and only such cash expenditure should be made as is necessary to make the system complete, serviceable, and convenient. It will be found on a great many farms that the two systems briefly outlined can be obtained for a moderate outlay of cash for the pump, sink, pipe, and fittings. In many cases the pump is already installed.

Thus by the proper utilization of material and labor available on the farm and by a small cash outlay, cleanliness, convenience, comfort, and economy in the water supply can be obtained, the value of which can not be estimated.

FLY TRAP.

Fly control should begin at the breeding places. All refuse or other substances in which flies may breed should be disposed of immediately. Fly traps should be placed around the house and stable and in places frequented by flies, so as to catch them whenever they appear. It is necessary to use bait to attract the flies. After they are caught they may be destroyed by pouring hot water over the trap and then burning the flies.

Any woman, without hammer or saw, can easily make the kind of fly trap shown in figure 22. The dimensions will depend upon the size of trap desired. Nonrustable screen wire should be used. A straight rectangular piece of screen wire is used for the cylinder or body of the trap. This is blanket stitched with heavy thread to prevent the wire from raveling. The cone is made of a circular piece of screen wire from which a sector or V-shaped piece has been cut, and a small hole is cut at the center which permits the entrance of the flies. A binding of heavy muslin or denim is sewed around the edge of the cone. The cone is slipped up into the cylinder. It must be large enough to fit tightly. It is made secure by the bound edge being sewed to the cylinder. The top of the trap is made of a circular piece of wire which exactly fits the top of the cylinder. On the edge of this piece is sewed a binding. On this edge is sewed a straight piece of wire 2 inches wide which forms the rim of the top of the trap. This top fits on the cylinder snugly and is held in place by pieces of tape. The legs of the trap are made of bended wire.

The trap should be thoroughly scalded every few days. The following may be used for baits—sour or skim milk to which a little sugar has been

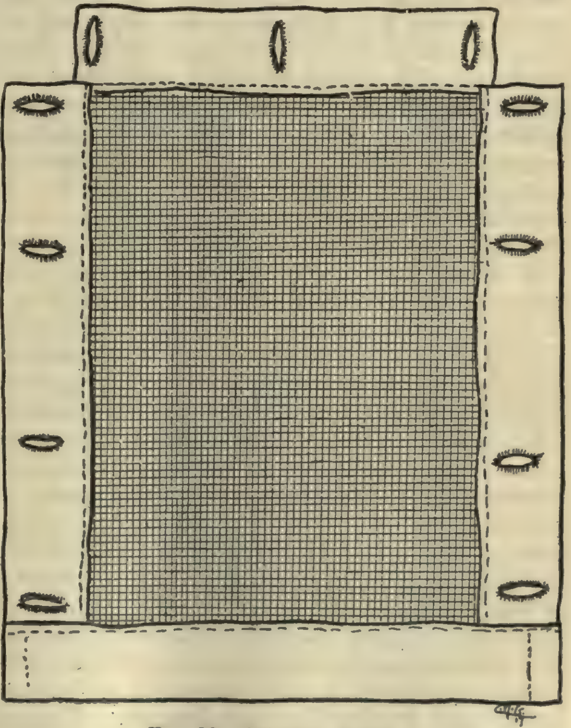

FIG. 23.—Window screen.

added; meat or fish scraps; bread and milk to which sugar has been added; and sugar, vinegar, and water.

WINDOW SCREEN.

All outside doors and windows should be screened. It will be economy to buy the screen doors. For both doors and windows use nonrustable screen wire.

A very cheap, convenient, and easily made window screen is shown in figure 23. Any woman can make this screen fit any window. Often in old houses window frames have warped and it is hard to make screen frames fit the windows.

Heavy denim or jeans or any other heavy material, of dark color, is cut into strips 4 inches wide. This is sewed around the edge of the screen, leaving about 2 inches of the doubled material as strips for eyelets. Eyelets are worked across the top and down the side strips. Small tacks are driven in the lower casing of the top window and down the sides of the window frames. The eyelets in the window screen are fastened over the heads of the tacks and thus the screen is held in place. This screen can only be used when upper windows can not be lowered and it can be removed easily when not needed.

COOKSTOVE DRIER OR EVAPORATOR.

Vegetables and fruits can be dried in an oven, in trays or racks over the kitchen stove, or in a specially constructed drier. There are small driers on the market which give satisfactory results. The small cookstove driers or evaporators are small oven-like structures, usually made of galvanized sheet iron, or of wood and galvanized iron. They are of such a size that they can be placed on the top of an ordinary wood or coal range, or a kerosene stove. These driers hold a series of small trays on which fruits or vegetables are placed after being prepared for drying. Portable outdoor evaporators are especially convenient when it is desired to dry as much as 10 bushels of fruit or vegetables per day. They are usually constructed of wood except the parts in direct contact with the heater. The homemade dry kiln used in some sections of the country can be cheaply and easily made of brick and stone.

A drier that can be used on a wood or coal range or a kerosene stove can be easily and cheaply made. (Fig. 24.) Dimensions: Base, 24 by 16 inches; height, 36 inches (including the height of the base). The drier can be made smaller if desired. A base 6 inches high is made of galvanized sheet iron. This base flares slightly toward the bottom and has two small openings for ventilation in each of the four sides. On the base rests a boxlike frame made of 1 or 1½ inch strips of wood. The two sides are braced with 1¼-inch strips which serve as cleats on which the trays in the drier rest. These are placed at intervals of 3 inches. The frame is covered with tin or galvanized sheet iron, which is tacked to the wooden strips of the frame. Thin strips of wood may be used instead of tin or sheet iron. The door is fitted on small hinges and fastened with a thumb latch. It opens wide so that the trays can be easily removed. The bottom in the drier is made of a piece of perforated galvanized sheet iron. Two inches above the bottom is placed a solid sheet of galvanized iron, 3 inches less in length and width than the bottom. This sheet rests on two wires fastened to the sides of the drier. This prevents the direct heat from

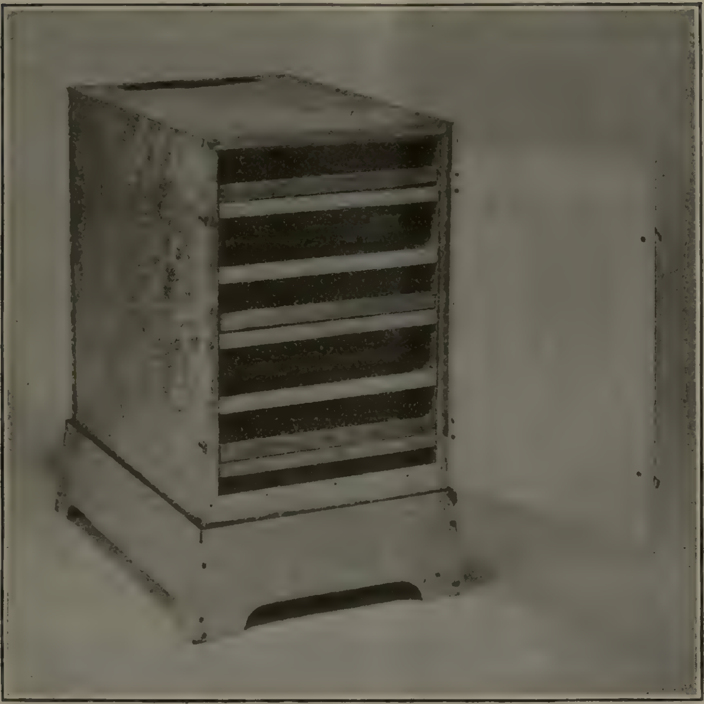

FIG. 24.—Cookstove drier or evaporator.

coming in contact with the product and serves as a radiator to spread the heat move evenly.

The first tray is placed 3 inches above the radiator. The trays rest on the cleats 3 inches apart. A drier of the given dimensions will hold eight trays. The frame of the tray is made of 1-inch strips on which is tacked galvanized screen wire, which forms the bottom of the tray. The tray is 21 by 15 inches, making it 3 inches less in depth than the drier. The lowest tray when placed in the drier is pushed to the back, leaving the 3-inch space in front. The next tray is placed even with the front, leaving a 3-inch space in the back. The other trays alternate in the same way. A ventilator opening is left in the top of the drier through which the moist air may pass away.

The principle of construction is that currents of heated air pass over the product as well as up through it, gathering the moisture and passing away. The current of air induces a more rapid and uniform drying. The upper trays can be shifted to the lower part of the drier and the lower trays to the upper part as drying proceeds, so as to dry products uniformly throughout.

THE CLEANING CLOSET.

Entrance of dust and dirt into a house is unavoidable, and the housekeeper is compelled to spend some of her time and energy in the daily cleaning. Through the use of better equipment and more systematic planning she is able to do the cleaning more easily and quickly. It is well to have a special place where cleaning utensils may be kept in the best condition and ready for instant use. Much time and energy is spent in collecting the utensils needed for cleaning.

A closet, cupboard, or wardrobe in the kitchen is the best place for keeping the cleaning utensils. A backstair closet is also a good place. One end of a back porch may be inclosed and used for such a purpose. The closet should have plenty of hooks and racks for utensils and a shelf for cleaning materials.

The housekeeper should choose utensils according to her own needs and according to the requirements of her house. Those suggested below are inexpensive and will help to lighten the work of cleaning:

Bucket with wringer for mopping.

A piece of inch board 15 inches square with rollers makes a convenient platform on which to set the mop bucket, and permits it to be moved easily without lifting.

Wall mop made by tying a bag made of wool or cotton cloth over an ordinary broom.

A broom, with a hook screwed in the end of the handle by which it can be hung up.

A long-handled dustpan.

Several brushes for cleaning purposes.

Cheesecloth, worn silk, and flannelette for dusters.

Dusters may be made by dipping pieces of cheesecloth in 2 quarts of warm water to which one-half cup of kerosene has been added. These cloths should be kept away from the stove or lighted lamp, as they are inflammable.

A blackboard eraser covered with flannelette for stove polishing.

An oiled floor mop to use on oiled or polished floors. Several makes can be found on the market, or one may be made of old stockings or any discarded woolen or flannelette material. The material is cut into 1-inch strips and sewed across the middle to a foundation of heavy cloth. This is fastened to an old broom handle or used in a clamp mop handle. The mop is dipped into a solution made of one-half cup melted paraffin and one cup kerosene and allowed to dry. To keep it moist, it is rolled tight and kept in a paper bag, away from stove or lamp.

A carpet sweeper or a vacuum cleaner should be used in the daily cleaning of the carpets and rugs. A vacuum cleaner operated by hand or electric power removes practically all the dust and dirt from carpets and rugs in a dustless manner.

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AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Farm Kitchen as a Workshop. (Farmers' Bulletin 607.)
Conveniences for The Farm Home. (Farmers' Bulletin 270.)
Homemade Fireless Cookers and Their Use. (Farmers' Bulletin 771.)
Home and Community Drying of Fruits and Vegetables. (Farmers' Bulletin 841.)
Plan for a Small Dairy House. (Farmers' Bulletin 689.)
Production of Clean Milk. (Farmers' Bulletin 602.)
A Simple Steam Sterilizer for Farm Dairy Utensils. (Farmers' Bulletin 748.)
Fly Traps and Their Operation. (Farmers' Bulletin 734.)
Sanitary Privy. (Farmers' Bulletin 463.)
The Use of Concrete on the Farm. (Farmers' Bulletin 461.)
The Use of Paint on the Farm. (Farmers' Bulletin 474.)
Clean Water and How to Get It on the Farm. (1914 Yearbook Separate 634.)
Water Supply, Plumbing, and Sewage Disposal for Country Homes. (Department Bulletin 57.)

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CONTROL OF THE ARGENTINE ANT IN ORANGE GROVES

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Insect Investigations

FARMERS' BULLETIN 928

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. March, 1918

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SEVERAL VERY INJURIOUS scale pests of orange would be much more largely controlled by their insect enemies were it not for the Argentine ant.

This ant is very fond of the sweet substance, known as honeydew, excreted by mealybugs and other soft scales and is always very attentive to them and prevents many of their insect enemies from approaching them. Thus the natural enemies of these pests are hindered in carrying on their good work. As a result, some of the soft scales become excessively abundant.

The Argentine ant does not obtain honeydew from the armored scales, but in patrolling the trees constantly in large numbers in search of insect prey it hinders, to a certain extent, the work of the natural enemies of these scales, and if the control of the scales be neglected for several seasons the infestation may be considerably increased.

In Louisiana orange groves this ant can be controlled as an orchard and house pest by the trapping method described on pages 12–17. Once the orchard has been practically rid of ants, which can be done in from 8 to 10 fumigations of the trapped ants, little work will be needed to keep them from causing further annoyance.

In California orange groves the ants can be prevented from getting into the trees by banding the trees in accordance with the instructions on pages 19–20, and their numbers can be reduced by poisoning. Recipes for ant poisons and directions for using them are given on pages 17–19.

CONTROL OF THE ARGENTINE ANT[1] IN ORANGE GROVES.

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INTRODUCTION AND IMPORTANCE.

THE ARGENTINE ANT was introduced first into the United States on ships arriving at New Orleans from tropical American ports. It has been known in New Orleans for at least 25 years, and probably has been reintroduced many times during that period. It made its way from Orleans Parish into Plaquemines and St. Bernard Parishes, along the lower Mississippi River, by rail and on coal barges, and now occurs in slightly more than one-fourth of the orange groves of Louisiana. It has become established widely in California orange orchards, and is especially numerous in some orchards in Los Angeles and Riverside Counties.

This ant is of first importance as a pest in houses, groceries, and candy and meat shops. It not only causes great annoyance by persistently getting into all foods containing sugar, fats, or fruit juices, and into meat, but sometimes gets into beds and into the mouth and nostrils of infants. It probably ranks near to the house fly as a disease carrier, as it is a frequent visitor at feces and other sources of infection and doubtless often nests in contaminated soil.

It has been rated as a very important pest of field and truck crops, on certain of which it is said to cause great increase of mealybugs and aphids. Sometimes it removes the seeds of certain kinds of vegetables from the ground before they have germinated, necessitating resowing and protection of the seed. The ant also has been a pest at times in greenhouses, where it occasionally cuts into certain flowers and fosters mealybugs and aphids.

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[1] *Iridomyrmex humilis* Mayr.

The general belief has been that in Louisiana the ant caused far more serious damage to the orange trees than to any other crop. It was thought to bring about a tremendous increase of all orange-infesting scales, white flies, and aphids, to destroy the blossoms and branches, injure the roots, greatly reduce the crop, and even kill the trees. In reality the ant is responsible for only one form of direct injury to orange trees. Rarely it chews into the petals and stamens of open orange blossoms for the purpose of squeezing out the sap. This occurs only on isolated trees, where food is scarce in comparison with the number of ants, and the amount of injury resulting is unimportant except on rare occasions. The ants habitually visit orange and other flowers to obtain nectar and to capture flower-feeding insects, but ordinarily do no damage to the flowers. The ant does not and can not injure sound oranges, although it enters and feeds upon the juice of broken ripe or rotting fruits.

The chief importance of the Argentine ant in orange groves is due to the fact that certain injurious scale insects become much more abundant as a result of its presence, and that it fosters mealybugs and aphids.

HOW THE PRESENCE OF THE ARGENTINE ANT FAVORS INCREASED INFESTATION BY SCALE INSECTS.

Two very distinct groups, or classes, of scale insects infest orange trees: (1) The armored scales, or those which settle permanently in a particular spot, lose their legs, and form a protective covering, such as a scale or shell, over the body. The eggs are deposited and the young hatch under the protection of this shell. The hard, flattened, apparently lifeless particles encrusting the branches and trunk and sometimes the fruit and leaves of orange trees are the armored scales. (2) The unarmored, or soft scales. These do not form a shell or scale over the body nor do they lose entirely their legs and the power of changing location. They are usually less flattened, softer, and, when mature, in most cases larger than the armored scales. Certain kinds, such as the mealybugs and the fluted scale, move about from one location to another throughout their lives. Others, such as the black, soft brown, and wax scales, usually settle down when partly grown and remain in one spot, though they are able to move about even in the later stages. The males of both classes of scale insects are minute gnatlike insects with wings.

The relations of the Argentine ant with the soft scales and aphids are direct and mutually beneficial. The ant is attracted to these insects for their honeydew, a sweet liquid which it induces them to excrete by stroking their bodies with its antennæ, or feelers. The honeydew of soft scales, aphids, and some other insects forms an important part of the food of the ants. In securing this sweet excretion the ants continually surround the scales and aphids and attack any other insects that attempt to reach them. In this way they afford considerable protection to the scale pests and make it possible for certain species which have numerous and effective predacious enemies to thrive and increase to the point of causing severe infestations.

The Argentine ant does not obtain honeydew from the armored scales, but in patrolling the trees constantly in large numbers in search of insect prey it hinders to a certain extent the work of the natural enemies of these scales, and if the control of the scales is neglected for several seasons the infestation is increased considerably.

Contrary to the general belief, the ant does not itself distribute the scales and aphids of orange trees to start new colonies, although an occasional ant is seen carrying living scales or aphids, or scale shells, to the nest for flesh food and for nest construction. Of course, wherever the abundance of scale insects has become greatly increased through the presence of ants, a more rapid spread of the scales through the usual agencies, such as winds, birds, etc., naturally follows.

THE ANT AND SOFT SCALES IN CALIFORNIA.

Mealybugs.[1]—Infestations of mealybugs of the orange have been increased greatly in Los Angeles County, Cal., by the Argentine ant. In this county the orange trees usually are kept free from other scale insects and in vigorous health, and under these conditions, when protected from their numerous predatory enemies by the ants, the mealybugs are able to thrive. These natural enemies effect a practical control of the mealybugs in many Los Angeles County orange groves in the absence of the ant. As a result of the attendance of the Argentine ant, infestations of three or four species of mealybugs other than the common one are increasing in number and severity, particularly in the Pasadena district.

Fluted scale.[2]—The fluted or cottony-cushion scale is almost, if not quite, as eagerly sought and as closely attended by the Argentine ant as are the mealybugs, owing, no doubt, to the large amount of thick excretion which it supplies. At present, however, the ant can not be said to cause the slightest injury to orange trees in California through its relations with the fluted scale. Infestations of this scale become as severe at times in some localities, whether the ant is present or not, as when the insect was at the height of its abundance in earlier years. During 1916, however, the insect was very scarce, even in the worst ant-infested orchards of Los Angeles, Riverside, and Ventura Counties, there seldom being more than one or two scales per tree. The chief factor in their control in California seems to be insect enemies, chiefly the Australian lady-beetle,[1] a parasitic fly,[2] and lace-winged insects;[3] but there appears to be some other unknown factor assisting.

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[1] *Pseudococcus citri* (Risso) and other species of Pseudococcus.

[2] *Icerya purchasi* Mask.

Black scale.[4]—In California the black scale is rated as the most important of all the citrus scales. It is generally held in check by annual or biennial fumigation. Whether ants are in attendance or not, infestation by this scale often becomes very severe and capable of causing a heavy loss of crop after a single season in which fumigation has been neglected. Sometimes infestation is greater in trees where there are no ants than in others of the same age and condition overrun by ants. The black scale has quite a number of natural enemies, including one or two intermittently effective internal parasites, but these enemies do not seem capable of keeping it under control; hence interference by the ant with the work of these enemies does not accelerate greatly the increase of the scale.

Soft brown scale.[5]—The soft brown scale is a favorite of the Argentine ant. In Riverside County, Cal., this scale appears to have increased considerably in certain ant-infested groves, especially where for a long time fumigation has been neglected. Ordinarily it is controlled along with other scales by fumigation and no special treatment for the ant is needed. In Los Angeles and Ventura Counties both the soft brown scale and the closely allied citricola scale[6] are scarce in ant-invaded as well as in ant-free orchards. On more isolated ornamental trees, bordering some of the streets of Pasadena where the ants have become numerous, the scales are much more numerous than where there are no ants.

The control of scales by fumigation in California makes it improbable that the ant will increase seriously the damage from the black and soft brown scales in those orchards where fumigation is conducted regularly, although annual fumigation may become necessary in all groves invaded by the ants. The control of the mealybugs will be facilitated greatly, and in many cases accomplished fully, by the protection of the trees from ants. There are no present indications that the ants will cause the fluted scale to become again a menace to the State.

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[1] *Novius cardinalis* Muls.

[2] *Cryptochaetum monophlebi* Skuse. (Identified by Frederick Knab.)

[3] *Chrysopa califorica* Coq. and possibly others.

[4] *Saissetia oleae* (Bern.).

[5] *Coccus hesperidum* L.

[6] *Coccus citricola* Campbell.

THE ANT AND SOFT SCALES IN LOUISIANA.

Mealybugs.—The ant has not had any such decided effect in increasing the severity of mealybug infestation in the orange groves of Louisiana as in those of California. The mealybugs usually start to increase rapidly in some groves of Louisiana in the spring and early summer and threaten to infest certain of them severely. But at some time between June 15 and August 1 they are brought under control by their natural enemies, regardless of the presence of the ants. The common mealybug[1] is at present held in check in the Louisiana orange groves partly by its natural enemies, partly by the overcrowding of the trees with armored scales and white flies, and partly by the poor condition of the trees. The insect does not cause the slightest damage to the orange trees, nor does it blemish the fruit, under present conditions in Louisiana.

Fluted scale.—The fluted scale never yet has been found in the orange groves of Louisiana, except in small and isolated plantings on the Metairie Ridge. It therefore may be dismissed with the citrus mealybugs as of no present importance as a cause of injury to orange trees in Louisana.

Black scale.—Although the black scale occurs in parts of New Orleans where the ants are most numerous, the ant has not yet caused any great increase of infestation there, and this scale has not come to the front as a pest, even of the ornamentals on which it occurs. It does not appear to be present in the orange groves proper of Louisiana.

Soft brown scale.—In the Louisiana orange groves the soft brown scale appears and disappears, being kept in check mainly by its internal parasites, against which the ants are relatively ineffective. The scales form in larger groups on occasional branches of an orange tree when attended by the ants than in cases where there are no ants. Occasionally trees are found having one or more small branches heavily infested, but even where the ants are most numerous the trees are not infested to a seriously injurious extent. The largest groups of soft brown scales occur on food plants other than orange trees in Louisiana.

From the foregoing it must be recognized that under present conditions very little damage is done to the orange industry of Louisiana by the Argentine ant through its relations with the unarmored, or soft, scales. Only four of the six principal kinds of orange-infesting soft scales occurring in this State have been found in the orange groves proper. At least two of these four, namely, the Florida wax scale[2] and the barnacle scale,[3] although attended by the ants, show no likelihood of ever becoming dangerously numerous. The fluted scale may gain an entrance into the orange groves, and under ant attendance and other favorable conditions may become a serious menace. There is probably little to fear from the black scale under the climatic and other conditions which obtain in Louisiana.

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[1] *Pseudococcus citri* (Risso).

[2] *Ceroplastes floridensis* Comst.

[3] *Ceroplastes cirripediformis* Comst.

THE ANT AND ARMORED SCALES.

The armored scales do not excrete honeydew or any similar liquid attractive to ants and, contrary to the general belief, are not attended by ants. They probably would become the prey of the ants if it were not for their protective shield, or scale. Ant shelters, or "cow sheds," sometimes occur over large and small groups of the armored scales, but the number of scales covered is so exceedingly small that it is unimportant. These shelters are erected for the protection of the ants and not for the protection of the armored scales. The ant does not disseminate any of the armored scales of citrus or colonize them upon new growth or new trees.

The ants eat all insects that they can capture except those supplying honeydew, and therefore they disturb certain enemies of the armored scales, and perhaps occasionally feed on the eggs of some of them. It therefore may happen that after two or three years of heavy and constant ant attendance, an orchard that is never sprayed or fumigated for the control of the armored scales may become more heavily infested by these scales than if ants were not present. Severe and injurious scale infestations may develop in a single year, in unsprayed orchards free from ants, as the natural enemies of the scales are not effective control agents. The injury caused by these scales, therefore, can not be prevented by destroying the ants. Direct control measures against these scales must be adopted and persistently practiced if orange growing is to be made profitable.

There are four important and destructive armored scales of orange trees in Louisiana—the purple scale,[1] chaff scale,[2] long scale,[3] and white scale.[4] The purple and chaff scales are by far the most numerous, generally distributed, and injurious, and for a long time have been among the leading citrus pests of Louisiana. The infestations of the armored scales are sometimes more severe where ants occur, sometimes more so where they do not, and are almost certain to be severe in untreated groves. These scales are more numerous on the present-day budded orange trees of Louisiana than they ever were in the seedling trees which formerly were common and which still are grown in large numbers in Cameron Parish, but this is due to the greater resistance of the seedling trees to scale infestation.

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[1] *Lepidosaphes beckii* (Newm.).

[2] *Parlatoria pergandei* Comst.

[3] *Lepidosaphes gloverii* (Pack.).

[4] *Chionaspis citri* Comst.

The purple,[1] red, and yellow scales are the most important armored scales on citrus trees in California, but these usually are controlled in this State by hydrocyanic-acid gas fumigation, the results of which are not interfered with by the ants. Judging from present information the ants do not appear to cause excessive infestations of any of these scales in California.

THE ANT AND THE ORANGE APHIS.[4]

Notwithstanding the fact that the common aphis, or "green louse," infesting orange trees appears to be desired less by the Argentine ant than are the soft scales mentioned, it always is attended directly and stroked by the ant for its honeydew. This aphis, furthermore, should receive quite as much benefit as the armored scales from the mere occurrence of the ants upon the trees, but it suffers heavily from internal parasites, whereas scales do not. The ants are ineffective against these little parasites, which often may be seen "stinging" and depositing their eggs in aphids, even while attended by the ants. The parasites are very small and active and nimbly avoid the ants.

The orange aphis becomes abundant on the tender growth in the spring in both Louisiana and California, and often increases during April and May, sometimes causing some of the leaves to curl. It disappears rapidly, and numerous dried remains, each with a circular hole through which a parasite has emerged, indicate the effectiveness of these little enemies. The parasites are aided in the destruction of aphids by certain lady-beetles, lacewings, and syrphus-fly larvæ, which are more or less immune to the attack of the ants. The parasites, however, destroy a very large proportion of all the aphids, and very effectively control them in ant-infested as well as all other orange groves of California and Louisiana. The Argentine ant, therefore, does not cause any important loss to the citrus industry through the orange aphis.

THE ANT AND THE CITRUS WHITE FLY.[5]

The Argentine ant does not attend or obtain honeydew from the citrus white fly. It is a direct enemy of this insect, the adults of which it captures in large numbers during the principal emergence periods. The ant sometimes is seen with immature stages of the white fly in its jaws, but these are usually pupæ from which the adult insect is almost ready to emerge and which the ant impatiently has seized. A varying proportion of the emerging white flies are captured by the ants, and in some cases for days at a time more than half of the foraging ants will be seen carrying these insects down the trees.

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[1] *Lepidosaphes beckii* (Newm.).

[2] *Chrysomphalus aurantii* (Mask.).

[3] *Chrysomphalus citrinus* (Coq.).

[4] *Aphis gossypii* Glov.

[5] *Dialeurodes citri* (Ashm.).

The continuous patrolling of the trees by large numbers of ants must have the same disturbing effect upon predatory insects which may feed upon the white fly as upon those which prey upon the armored scales. Nevertheless, these enemies do not prevent extremely heavy white-fly infestation in orchards where there are no ants, whereas in groves in which ants are extremely numerous the amount of white-fly infestation often is small.

PREVENTION OF INJURY TO ORANGE TREES.

In Louisiana the damage resulting to the orange industry from the presence of the Argentine ant may be prevented largely by one or more of the following measures: (1) General improvement in orchard cultural practices, including the control of such orchard pests as the armored scales, the white fly, and the rust mite. (2) Direct measures for the destruction of the ant colonies and the use of ant barriers.

In California the means of preventing injury and controlling the ant are somewhat different. The armored scales are controlled by standardized methods of fumigation;[1] and other orchard practices also are standardized to some extent. Banding, as described on pages 19 and 20, to keep ants from ascending and descending the trees, and poisoning (see pp. 17–19), appear to be the most promising methods of control in that State.

BETTER ORCHARD CULTURE AS A PREVENTIVE OF INJURY IN LOUISIANA.

In Louisiana the first step toward preventing injury by the Argentine ant should be the control of the armored scales, through which most of this injury occurs, and the improvement of orchard practices in general. The destruction of the ants will not remove the necessity of controlling the armored scales and other principal pests, nor will it prevent injury due to faulty cultural conditions.

Orange growing in Louisiana never has received the care and attention that it merits, and it is capable of much greater commercial development than it has yet attained. In the earlier days citrus trees were grown there mostly for ornamental purposes or in small yard plots supplying only enough fruit for home consumption. Then followed small groves, almost exclusively of hardy seedling varieties largely resistant to insect pests, the fruit from which represented almost clear gain, no money having been expended to grow it, and the profits merely supplementing those from more important sources.

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[1] See Farmers' Bulletin 923, "Fumigation of Citrus Trees," which may be had free on application to the Division of Publications, United States Department of Agriculture.

Most of the present plantings are budded trees set out since the great freeze of 1899, which killed to the ground every orange tree in the State. These trees are much more susceptible to injury from insects and other natural influences encountered in Louisiana than are the seedling trees. The nursery stock was largely of inferior quality, and the trees usually were planted too close together in shallow, wet soil, which encourages the roots to cover a great area close to the surface. The insect pests were allowed to flourish unchecked, all cultural care was neglected, and many of the trees were damaged further by floods, storms, and freezing. As a result a large proportion of them have remained undersized and in poor health. The amount of production has never reached that of normal healthy trees, and at from 7 to 10 years of age both trees and crop began to fail. The maximum production of Louisiana orange trees was but slightly more than three-fourths of a box per bearing tree, and the present production is only about one-half of a box per tree.

The success of certain well-tended orange groves in Louisiana demonstrates that oranges can be grown with profit in the State. The only commercially successful and profitable groves, however, have been those which receive an amount of care and attention much above the average for the State. The Argentine ant now occurs in slightly more than one-fourth of the Louisiana orange groves.

Comparison of the condition of the trees and the amount of the crop in ant-invaded groves with those in groves in which there are no ants shows that only about one-sixth more of the trees of the former are in poor condition than of the latter, while the average reduction in crop is only about one-fifth greater per tree in ant-invaded groves. This difference probably is due largely to the greater neglect of ant-infested trees because of discouragement at the invasion of the ant.

There are, of course, a number of groves in Louisiana that consist of trees of such poor quality and in such a run-down condition that they will never repay the cost of reclamation. There are others, however, that can be so improved by spraying, cultivation, and pruning that the production will be more than doubled in a single season and still further increased by continued treatment.

In Louisiana, therefore, the improvement of cultural conditions and the control of the armored scales, white fly, and rust mite, the principal injurious pests, are absolutely imperative if orange growing is to be made successful, even where the Argentine ant is not present. These insects can be controlled, even with the ant present, by following a properly arranged program of spraying,[1] and they can not be controlled by the destruction of the ant alone. Presence of the ants will not interfere with the control of these pests by spraying.

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[1] For effective insecticides and directions for spraying, see Farmers' Bulletin 933, "Spraying for the Control of Insects and Mites Attacking Citrus Trees in Florida," which may be obtained free from the Division of Publications, United States Department of Agriculture.

TRAPPING THE ANT IN LOUISIANA.

In Louisiana, owing to heavy annual rainfall, the ant colonies can be collected in specially constructed traps and destroyed, a thorough control thus being effected at moderate expense. Moreover, if this method be followed diligently, permanent control, which at the same time will eliminate the ant as a household pest, will be achieved. This is by far the best and most practicable means of destroying the Argentine ant in the orange groves of Louisiana.[1] It is the only method adapted to ant destruction in large groves and can be used equally well in house lots. The trapping method of destruction is based on the fact that the ants can be induced to concentrate in populous colonies in artificial nests to avoid rain and can there be conveniently killed by fumigation. The trap box meets every nesting requirement of the ant under Louisiana conditions. Not only are rains and cold excluded, but to a large extent draughts and light also. Larger numbers of ants will mass together in numerous small colonies than in a few

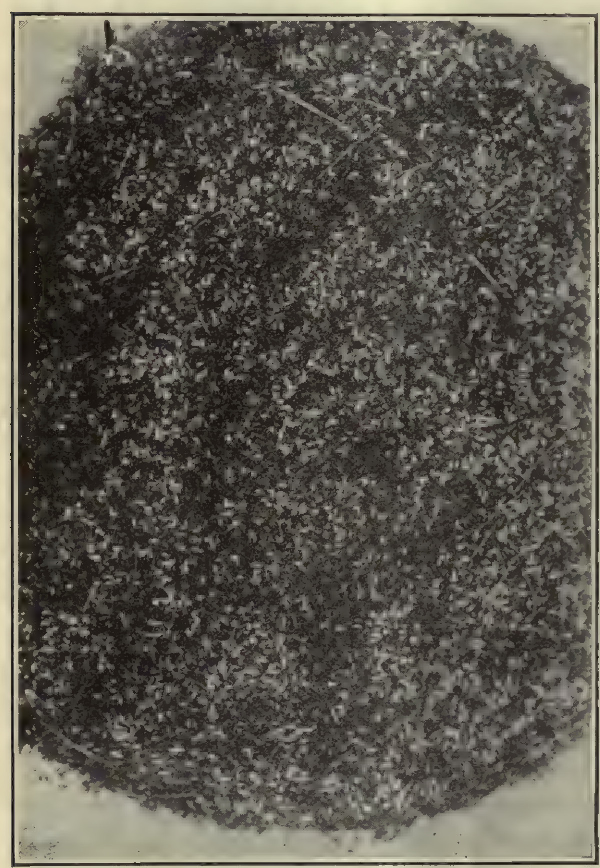

FIG. 1.—Average killing of Argentine ants in ant trap used in Louisiana orange groves.

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[1] The discovery that the ants would nest in large numbers in boxes of decaying vegetation in winter was first made by Messrs. Newell and Barber, who describe a method of destroying them based on this fact. (See U. S. Dept. Agr. Bur. Ent. Bul. 122, p. 95–96.) The trapping method described in the present bulletin depends upon the nesting of numerous small colonies, that is, colonies averaging only from 100 to 160 queens each, in a specially devised trap box which excludes rain.

extremely large ones. The traps are therefore small and a rather large number per acre are used. An average-size mass of ants killed in one of these traps is illustrated in figure 1.

CONSTRUCTION AND COST OF TRAPS AND FUMIGATING COVERS.

The trap (figs. 2 and 3, A) is made of ⅞-inch sap pine and consists of the following nine pieces:

Two sides 12 by 12 inches.
Two sides 10 by 12 inches.
One bottom 10 by 10 inches.
Two top pieces 8 by 12 inches.
Two pieces triangular molding 12 inches long.

First the smaller sides and bottom are fastened together, then the larger sides added. Rosined nails or screws should be used in order to prevent separation at the seams and resultant enlargement of the box to a size too great for the fumigation cover. The top pieces are fastened together in the form of a gable with a tight joint, this roof merely resting, loose, upon the top of the box to exclude rain. The pieces of molding are nailed across the inner sides of the roof to hold it in place.

A cover to keep the gas in while fumigating is made of 28-gauge galvanized iron, consisting of one piece 38 by 13¼ inches, bent into two right angles, forming two sides and the top, and two pieces 13¼ by 13¼ inches, forming the other two sides. The edges of the latter two pieces are folded over those of the first piece and hammered tightly together. Covers with hammered seams are suitable if very well made, but soldered seams are to be preferred, although they may be slightly more expensive. The completed cover (fig. 3, B) should measure 12½ by 12½ inches inside, after a margin of one-fourth inch has been turned down all around the edge to reinforce it.

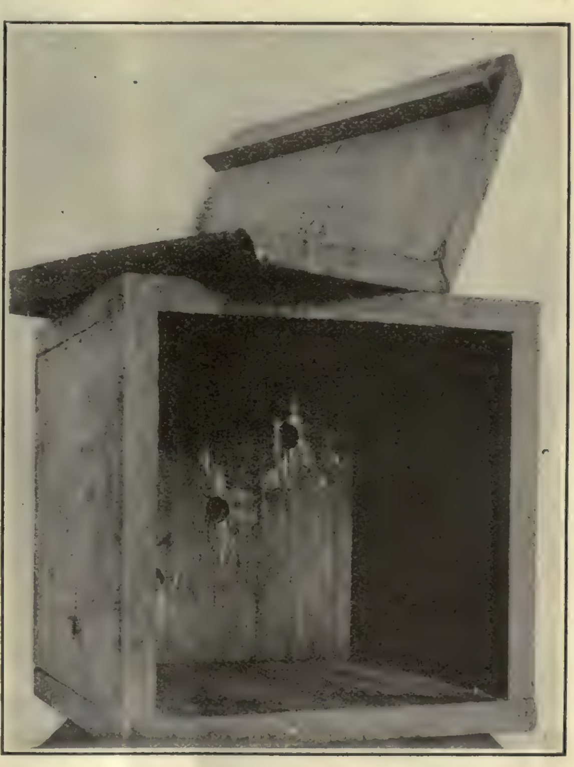

FIG. 2.—Trap used in destroying the Argentine ant in the Louisiana orange groves. (Note.—There should be only a single hole in the bottom to connect with the ant galleries under the trap.)

The cost of the traps, based on the price paid for 400 of them used in experimental work in 1914, would be about 31 cents each. The traps in question, made of C-grade sap pine, all parts cut to fit by the milling company furnishing the lumber, were supplied knocked down at 23 cents each, to which there was an additional charge of 8 cents each for transportation and setting up. The cost of the fumigating covers, based on the purchase of 48 of them in 1914, would be about 75 cents each, delivered.

PREPARING THE ORCHARD AND SETTING THE TRAPS.

The favorite rainy-weather nesting places of the ant are under loose boards, boxes, logs, sacks, and other loose pieces of cloth, and in piles of lumber or bricks, dead weeds, etc. The ants also nest in the walls of buildings when opportunity offers. They seek the higher, better drained ground in wet weather, and usually the larger colonies will be found on ditch banks and the high ground at the base of the trees.

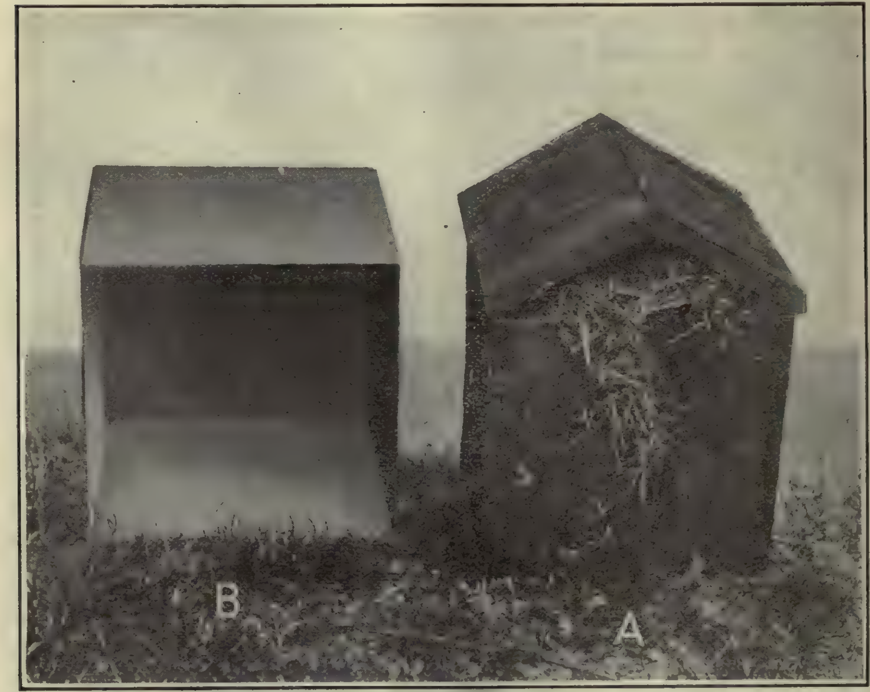

FIG. 3.—Trap (A) and gas-tight cover (B) used in destroying the Argentine ant in Louisiana orange groves.

In order to induce more rapid concentration of the ant colonies in the traps, the orchard as far as possible should be kept free from suitable natural nesting places. It should be cleared of loose boards and all similar materials under which the ants might collect. Piles of dry weeds, cowpeas, and prunings from the orange trees should not be allowed to collect in the grove, and stacks of lumber should be set upon posts banded with the adhesive recommended on page 20, to keep the ants out. The grove should be clean cultivated, from March to September, by plowing and disking both ways of the grove three or four times during that period. Even the cover crops should not be grown during the first season of trapping, or until a very large part of the ants have been destroyed.

There should be at least 25 traps to the acre of 100 trees, and the destruction of the ants will be accomplished much more rapidly if twice that many are used. If 25 are used, one trap should be placed near every other tree in each direction. For example, starting with the first orchard row, set a trap near each of the first, third, and fifth trees, etc., throughout the length of the row, then similarly in the third, fifth, and seventh rows, etc. The traps should be located just under the outer spread of the trees, where they will not be in the way of the cultivator or so close to the tree that it will be injured by the carbon disulphid gas. At a distance of about 4 feet from the trunk the trap still will be on the tree hill and there will be no danger of injury to the tree from the fumigant. The trap should be placed upon a slight, level elevation made by throwing up and smoothing off a few shovelfuls of soil.

The number of covers necessary will depend upon the number of traps and the conditions of labor. In experimental work with 415 traps, 48 covers could be operated most economically in fumigating, as a crew of three could handle this number without loss of time between setting and removing the covers. Therefore the proportion of covers may be estimated roughly at 12 per 100 traps, or 3 per acre of 25 traps, where 300 or 400 traps are used.

In winter the traps should be filled with damp but not wet stable manure and dry weeds or straw, the manure occupying the lower half of the box. In summer the manure, which is used principally for its heat, may be omitted. Maggots of the house fly, and perhaps other insects which inhabit the manure, serve as an added attraction to the ants. It is important to keep the lids always on the traps, to keep out rain and darken the nest, and to help retain its warmth in winter. As rain is by far the most important factor in driving the ants into the traps, many more ants will be destroyed by trapping in summer than in winter.

METHOD AND COST OF FUMIGATING THE TRAPS.

When the traps are full of ants and ready for fumigation the lids are removed, 2 fluid ounces of carbon disulphid poured in, and the covers slipped on and banked with soil, one shovelful being tamped down at each side to help retain the gas. The traps must be fumigated for one hour. Two ounces of carbon disulphid per trap of 1 cubic foot capacity, for one hour, kills all stages of the ants in the traps and for 3 inches in the ground beneath, as well as worms, sowbugs, etc., inhabiting the soil.

Once fumigation is started, it should be completed in 4 or 5 days, or before possible dry weather may cause the ants to leave the traps. If the number of traps is small, one man can conduct the fumigation, but where there are 300 or 400 or more traps the work can be done most efficiently by a crew of three, one to carry and measure the insecticide while the other two remove and reset the covers and bank with soil. Such a crew, working continuously, can handle 48 fumigating covers, removing them from one lot of traps and placing them over the next in from 50 minutes to one hour. Three men can fumigate over 1,000 traps in 4 days.

The same trap filler may be used indefinitely, but it and the traps must be aired thoroughly after each fumigation. The filler should be spread out on the ground and the traps turned up to the sun for several hours before resetting.

The cost of installing and operating the ant traps, based on the prices prevailing in 1914–15, would probably run about as follows, per acre of 100 trees:

25 traps at $0.31 each	$7. 75
3 covers at $0.75 each	2. 25
Net cost of traps and fumigating covers per acre	10. 00

In practice a crew of three have fumigated 400 traps in 1½ 8-hour days; their services, at the rate of $1.25 per day each, cost $5.62. The price of carbon disulphid prevailing in 1915 was $10.75 per hundred pounds. On this basis the cost of fumigation, with the use of 25 traps per acre of 100 trees, would be about as follows:

Cost of labor, fumigating 25 traps at $0.014 each	$0. 35
Cost of insecticide, 25 traps at $0.013 each	. 325
Net cost of fumigation per acre	. 675

From five to eight fumigations about one month apart will be necessary to reduce the ants to an inconsiderable number in the orange grove.

USE OF DRAINAGE DITCHES TO PREVENT REINFESTATION.

The orange grove will be rid of ants more rapidly if reinfestation is prevented by means of barrier ditches. This means of preventing the spread of ants is well known in Plaquemines Parish, where some of the growers have adapted drainage ditches to this use. Where drainage ditches already have been dug around three sides of the orchard, as is the case in many orchards, they need only to be cleared of weeds and provided with divided bridges which ants can not cross (figs. 4 and 5) to adapt them for use against ants. On the lower land subsurface water will remain in the ditches practically throughout the rainy weather. In higher sections it will be necessary at times to flood the ditches with water from the river by means of rice-irrigating siphons. The water can be siphoned over the levee in the high-water stage, but must be forced over with gasoline engine and pump during the low stage. The ants spread very little by flight, but will travel far in the usual trails to nest in the traps, food usually being plentiful in the orange trees near at hand.

COOPERATIVE AND COMMERCIAL TRAPPING.

By cooperative trapping, in which all the landowners in a given section club together to purchase traps and insecticide, the ants can be destroyed more thoroughly and rapidly than if each one should undertake the work on his own account. Special crews could be trained to carry on the fumigation efficiently, and the cost of the traps and insecticide would be reduced by purchasing in large quantity. The trapping method also might be put to use in southern Louisiana by commercial concerns, which could undertake to rid the land of ants at so much per acre.

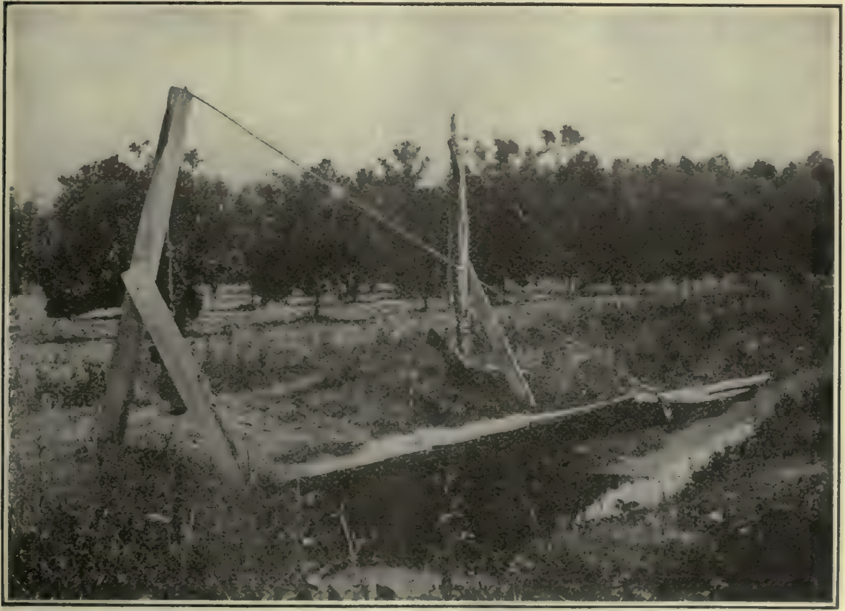

FIG. 4.—A bridge which the Argentine ant can not cross. (Newell and Barber.)

USE OF POISONED BAITS[1] AND ANT BARRIERS.

POISONING THE ANTS.

Destruction of the Argentine ant by means of poisoned sirups and other baits in orchards where orange trees, weeds, and windbreaks or borders of ornamental plants are left accessible to the ants is too slow and uncertain to be of practical value. Under such circumstances only a small proportion of the ants will be attracted from the natural sources of food in the trees and weeds, as they soon learn the injurious nature of the poison and ignore it, while continuing to feed at the usual near-by sources of supply.

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[1] For a discussion of the control of the Argentine ant in the household, the reader is referred to Bulletin No. 377 of the United States Department of Agriculture, "The Argentine Ant: Distribution and Control in the United States."

It is absolutely necessary, therefore, if satisfactory results are to be obtained by this method, that all sources of food other than the poisoned bait be eliminated so far as possible. This involves clean cultivation and the banding of all trees, orange and ornamental, with a mixture that will keep the ants out. Tree-banding alone in some cases will cause a large proportion of the ants to migrate to another locality in search of food and, as long as maintained, will have the desired effect of preventing injury to the trees from the ants.

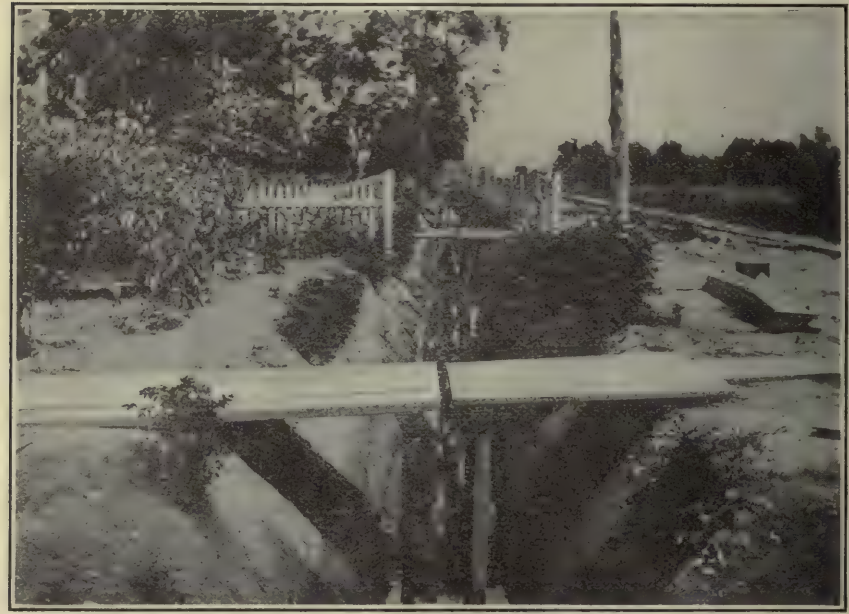

FIG. 5.—Bridges which the Argentine ants can not cross. (Newell and Barber.)

Although the employment of poisoned baits in accordance with the instructions given below often may prove practicable and effective in ridding yards where there are comparatively few trees infested by ants, this method can not be recommended for general orchard use in Louisiana as a substitute for the trapping method.

In preparation for the poisoning work, the premises should be first freed of weeds, long grass, vines, and other plants that can not be banded to keep out ants and that harbor aphids and scale insects. Then all the trees should be banded in accordance with the directions on page 19. The ant poison then should be distributed liberally about the premises, in containers that will keep out rain. One-pint fruit jars, of the type illustrated in figure 6, are suitable for this purpose. A single hole is punched in the center of the lid for the admission of the ants. A piece of sponge is placed in each jar to aid the ants in reaching the poison. Scrap or waste sponges suitable for this purpose sell for about 25 cents per pound at drug stores, and 1 pound of them will serve for a dozen or more jars. About one-half pint of sirup will serve for each jar. The jars should be laid on their sides, and occasionally shifted to a new position.

The best poison is prepared as follows: Make a sirup by stirring 8 pounds of granulated sugar in one-half gallon of cold water until dissolved, making 1½ gallons of sirup. Then add 4½ ounces of chloral hydrate crystals, previously dissolved in a small quantity of water, and about one-half pound of strained honey. The honey will add to the attractiveness of the sirup.

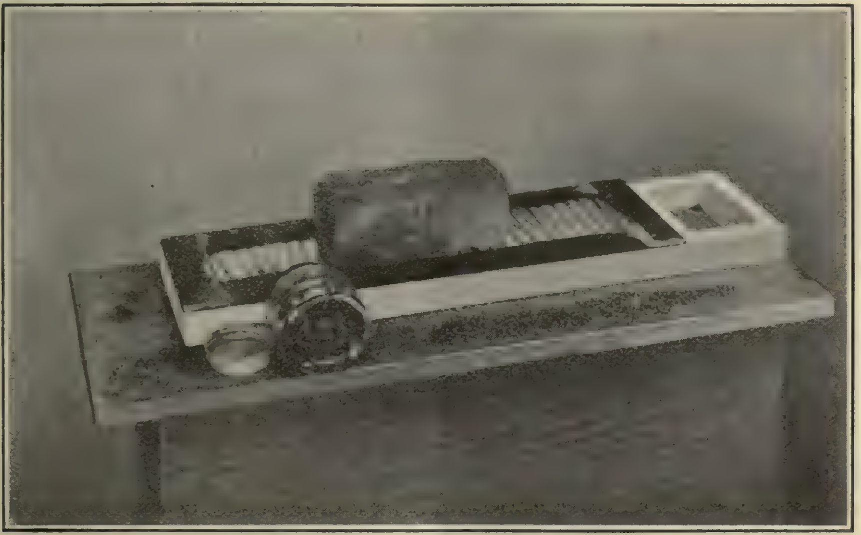

FIG. 6.—Artificial ant nest and jars used in poisoning the ants.

If chloral hydrate can not be obtained, arsenite of soda may be substituted. Dissolve 62 grains of tartaric acid crystals in 3½ pints of water. Then add 8 pounds of granulated sugar and boil until dissolved. Allow to cool. Dissolve about 200 grains of arsenite of soda (or 172 grains of white arsenic) in one-half pint of hot water. When cool add to the sirup. Then add from one-half to three-fourths pound of strained honey. The tartaric acid prevents the souring of the arsenical sirup, which the ants will take very slowly.

USE OF TREE-BANDING MIXTURES.

In Louisiana orange groves the extensive use of adhesive and other repellent mixtures for banding tree trunks to keep out ants is not recommended in view of the more positive method of destroying the ants by trapping. When used on a large scale, even the best bands of this sort will need more or less frequent inspection and renewal or respreading. Although the first cost of banding possibly might be less than that of installing traps, the cost of permanent maintenance would exceed the cost of trapping, and under present conditions would not be justified by the increased crop returns. Tree banding would cost more in Louisiana than in California, as in most cases an average of three bands would be required for every orange tree banded in Louisiana, owing to the growth habit of the trees. Furthermore, such barriers do not reduce the ant population, and therefore can not be considered a positive means of control. In Louisiana, therefore, the chief use of these mixtures will be found in protecting yard trees and beehives from the ant and in keeping it out of food supplies, beds, etc., in the house.

The most effective adhesive type of banding mixture, determined from much testing of various materials and combinations of them, is composed of 1 part by weight of flowers of sulphur to 6 parts of commercial tree adhesive. All the lumps in the sulphur should be broken and the two ingredients mixed thoroughly together without heating, a wooden paddle serving this purpose. The sulphur not only keeps the adhesive soft, but also has a sufficiently repellent effect upon the ants to prevent their bridging the bands with bits of trash or their own bodies.

Bands of this material will remain effective in rainy, foggy, or exceptionally dry weather for from three to five months, and in the cool weather of fall and winter as long as the ants are able to forage out of doors. If directly exposed to the sun for long periods, however, the surface of the bands becomes hard enough for the ants to cross. The bands, therefore, must be applied where the shade of the tree will protect them. The trees must be pruned so that branches will not touch the ground, and weeds must be prevented from touching the tree above the bands and allowing the ants to cross. The mixture should not be applied directly to the bark, as it would be absorbed to some extent and in time might injure the tree. First the trunk should be wrapped snugly with tire or hose-mending tape for a space about 6 inches wide, and then the adhesive should be applied over this in a band about 4 inches wide and one-fourth inch thick.

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THE PLACE OF SHEEP ON NEW ENGLAND FARMS

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CONDITIONS CREATED by the European war have made sheep raising on a small scale a very profitable enterprise for the New England farmer so situated as to take advantage of the economic conditions.

Prior to the recent remarkable advance in prices of wool and mutton, sheep raising in New England was comparatively unprofitable, but now, under certain conditions, a revival of the industry seems desirable.

This bulletin tells briefly how the industry was organized in 1914, and discusses the difficulties to be met in expanding the business, with special reference to improvement in breeding stock, better care, and more efficient disease control.

THE PLACE OF SHEEP ON NEW ENGLAND FARMS.

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RAPIDLY CHANGING economic conditions, such as the increase in the cost of commercial feeds, scarcity of labor, and the increase in prices of wool and mutton, have induced many farmers in New England, as well as those in other North Atlantic States, to turn their attention with renewed interest to sheep raising. Those already keeping sheep intend to increase the size of their flocks, while others are thinking of putting on sheep, some to the exclusion even of dairy cattle. Present prices of sheep products are attractive and in themselves likely to stimulate interest in sheep raising, and there is no doubt that there are conditions in the eastern part of the country under which an increase in the number of sheep kept is justifiable. However, no material reduction in the number of dairy cows to make place for sheep should be made without a careful consideration of the limitations of the sheep business and the relative returns from each of these live-stock enterprises.

PURPOSE OF BULLETIN.

Farm management studies conducted in New England during the summer of 1915 by the Office of Farm Management have made available figures which show what the returns from sheep and dairy cattle have been on many farms, and which, when considered in the light of present-day prices, give an excellent indication of what may now be expected from each industry.

It is the purpose of this bulletin to show:

1. The relative importance of the industry and the place that sheep now occupy on New England farms.

2. The returns from sheep as compared with dairy cattle.

3. The more important difficulties experienced by sheep growers and the practices followed in handling these troubles.

The conclusions arrived at are based on actual figures obtained from a large number of farms representing the three States in New England in which most sheep are found, and upon the opinions of farmers keeping sheep under present-day conditions. The locations of the areas studied are shown in figure 1.

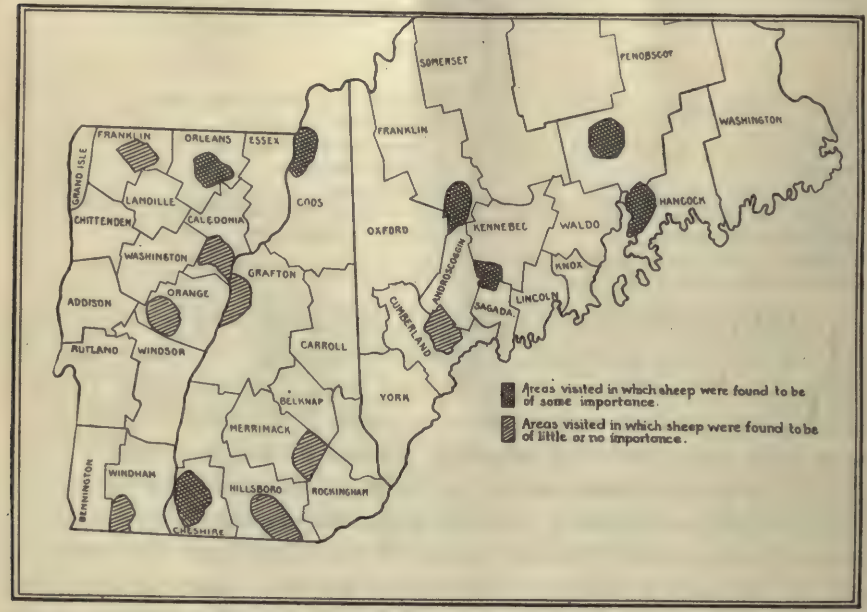

FIG. 1.—Location of areas in New England visited in farm management study of sheep.

AREAS IN WHICH SHEEP WERE OF SOME IMPORTANCE.

State.	County.	Township.	State.	County.	Township.
Maine	Penobscot	Corinth.	New Hampshire	Cheshire	Walpole.
	Hancock	Bucksport.		do	Surrey.
	do	Orland.		do	Gilsum.
	Franklin	Farmington.		do	Westmoreland
	do	Wilton.		do	Keene.
	do	Jay.		do	Swansey.
	Kennebec	Winthrop.	Vermont	Orleans	Irasburg.
	do	Monmouth.		do	Brownington.
New Hampshire	Coos	Stewartstown.		do	Barton.
	do	Colebrook.		Windham	Wilmington.
	do	Columbia.		do	Whitingham.

AREAS IN WHICH SHEEP WERE OF LITTLE OR NO IMPORTANCE.

Maine	Cumberland	Gray.	New Hampshire	Hillsboro	Milford.
	do	New Gloucester.		do	Hollis.
New Hampshire	Grafton	Bath.	Vermont	Franklin	Franklin.
	do	Haverhill.		do	Berkshire.
	do	Piermont.		do	Sheldon.
	Merrimac	Louden.		do	Enosburg.
	do	Pittsfield.		do	Bakersfield.
	do	Chichester.		Caledonia	Peacham.
	do	Epsom.		do	Barnet.
	do	Pembroke.		do	Ryegate.
	Hillsboro	Lyndesboro.		Orange	Randolph.
	do	Amherst.			

CONCLUSIONS.

Following, in brief, are the more important conclusions drawn from this study:

1. Sheep raising in New England is, at the present time (1917), a relatively small, but, highly profitable business if properly managed.

2. It is believed that the sheep industry could be greatly increased without a material decrease in the number of profitable dairy cows.

3. On most farms adapted to sheep raising, sheep should be kept in small flocks, though much larger than the present average, in conjunction with other kinds of live stock.

4. Sheep, because they require comparatively little grain and labor, are particularly well adapted to many farms located far from market or to such as have abandoned other forms of live-stock farming because of the high cost of these commodities.

5. As conducted at present, there is great need for the improvement of the sheep industry in New England, particularly with reference to more careful selection of breeding stock, better care, and disease control.

6. Good care is a vital factor in its bearing upon the profitableness and development of the New England sheep industry, and its importance can not be overemphasized. Except possibly for disease, it is believed more failures in the sheep business are due to lack of proper care than to anything else.

7. The disease factor is one of paramount importance, which, together with low prices, seems to have had much to do with driving the sheep business from the East, and which is still of much concern to the New England sheep breeder.

8. The dog question is a serious one still, but a marked improvement in public sentiment is evident and there is good prospect of further legislation designed to protect the sheep grower in this regard.

9. The question of breed seems comparatively unimportant so long as the sheep kept are of one of the mutton breeds, careful selection and good care counting for more than the breed.

PRESENT STATUS OF THE SHEEP INDUSTRY IN NEW ENGLAND.

At present less than one-eighth as many sheep are kept in New England as were kept from 65 to 70 years ago. In 1850, according to the Federal Census, there were approximately 2,257,600 sheep (exclusive of lambs) in New England, whereas in 1910 there were only 306,400, the decline having been rather constant during that interval. Since 1910 the decline has continued as previously, and, as estimated by the Department of Agriculture, the number of all sheep in New

England on January 1, 1918, was but 360,000. The ratio of this number to the number on hand in 1850 is as 1 to 6.3.

Figures obtained for this study check very closely with 1910 census data in showing that at present about seven-eighths (86.7 per cent) of all sheep in New England are found in Maine, New Hampshire, and Vermont. Of these three States, Maine has more sheep than New Hampshire and Vermont combined, or nearly one-half of all in New England. In Maine practically 1 farmer in every 5 (18.6 per cent) keeps sheep; in New Hampshire and Vermont 1 in every 10 (10.1 per cent), while in the rest of New England as a whole an average of only 1 farmer in 50 keeps sheep. As will be shown later, sheep in any of these States are confined to certain regions, so that the ratio of farmers with sheep to all farms would be somewhat greater in regions where sheep are found than is indicated by the figures given, which apply to the States as a whole.

On the farms on which sheep are kept these animals constitute about one-fifth of all productive live stock (all live stock except work animals), and at prices prevailing prior to 1916 contributed slightly less than 6 per cent toward total farm receipts. At present prices this percentage would probably be about doubled.

SHEEP KEPT IN REGIONS RELATIVELY UNFAVORABLE FOR DAIRYING.

Reference to the map (p. 4) shows eight districts visited in which sheep were comparatively important and seven other districts in which sheep were of very little or no importance. A study of these regions and of the kind of farming carried on in them shows that for the last few years, at least, sheep in New England have not been kept to any great extent in regions well adapted to dairying and that those regions in which sheep have been most extensively kept are somewhat lacking in the natural advantages of a typical dairy section.

It must not be inferred from this that dairy farming is of no account in regions where sheep are found. Dairying is carried on on many farms in these regions and, as will be seen later, on farms with sheep, but for the regions as a whole it was found that the keeping of beef cattle was much more common and that the business of dairying was of relatively small importance. Fewer cows were kept in these regions; a considerable portion of the cows kept were of beef breeds, and dairy products contributed far less toward the total farm receipts than in areas where sheep were of no importance.[1] In the regions with the sheep one farmer in every five kept beef breeds of cattle, while these breeds are scarcely to be found in the areas studied with no sheep. The relative unimportance of dairying in regions where sheep raising is more common is in large measure due to rougher pasture not so well suited to the needs of dairy stock, remoteness of farms from market, and generally poor market facilities.

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[1] Areas with sheep as a whole had an average of only 9 cows per farm, and receipts from dairy products amounted to but $510, while areas where sheep were of no account had an average of 15 cows per farm and receipts from dairy products amounted to $1,070.

KEPT MOSTLY IN SMALL FLOCKS WITH OTHER LIVE STOCK.

Sheep in New England are kept mostly in small flocks. A few large flocks consisting of 200 or more ewes are known, but such cases are indeed rare. Farm flocks usually number from 15 to 30 ewes, the average number on the 137 farms from which records were obtained being 23. A few farmers kept less than 15 ewes while only about 1 farmer in 5, in the regions studied, kept more than 30 ewes.

Practically all flocks are kept on farms with other live stock. An occasional small farmer who derives the most of his income from the sale of crops or fruit, or from labor off the farm, keeps a small flock of sheep (in addition to a little other stock for family needs) as the only kind of live stock yielding cash income. About one-tenth of the flocks upon which records were obtained were kept in this way; one-half were kept on dairy farms, while the remaining two-fifths were found on farms which kept beef cattle as the principal kind of live stock.

DO NOT DISPLACE OTHER KINDS OF LIVE STOCK.

Kept in these small numbers, sheep do not displace other kinds of live stock, but are kept in addition to the regular quota of other stock on such farms as have extra pasture available. It was found that, regardless of whether sheep were kept in conjunction with dairy or with beef cattle, farms with sheep had practically the same kinds and numbers of other live stock as did farms without sheep.[1] Moreover, farms with the sheep had an average of 15 more acres of pasture than did farms without the sheep,[2] warranting the conclusion that sheep in New England have not been kept to the exclusion of other live stock, but have been kept on farms with large pasture areas to utilize the extra pasture available.

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[1] In making this determination it was first found that swine and poultry, which do not usually require pasture as kept in New England, were kept in about the same numbers on farms regardless of sheep. All cattle were then reduced to a mature animal basis (counting 2 head of young cattle as the equivalent of a mature cow) and the average number of pasturable animals (mature animal basis) determined for farms with and for farms without sheep. Following this method, it was found that 68 dairy farms on which sheep were kept had on an average the equivalent of 16.1 mature cattle in addition to 22 sheep, while 298 dairy farms of comparable size, but without the sheep, had the equivalent of 16.3 mature cattle. Likewise 54 farms keeping sheep in conjunction with beef cattle had on an average the equivalent of 15.4 mature cattle in addition to 24 sheep, while 60 beef-cattle farms without the sheep had the equivalent of 15.5 mature cattle.

[2] Farms with sheep had an average of 85 acres of pasture, while those without sheep had 70 acres.

SHEEP FOUND ON LARGE FARMS WITH LOW-PRICED LAND.

Pasture is a prime essential to sheep raising, and it has been shown that only such farms as have pasture above the needs of other stock have kept sheep. As would be expected from the nature of New England land, such a pasture excess is to be found on the larger farms only. In the areas studied sheep are scarcely ever kept on farms of under 100 acres.[1] On farms above this size, flocks gradually became more common, occupying the most prominent place as a farm enterprise on farms of 200 acres or more, where they are kept on about one farm in every three and in comparatively large flocks. The 122 farms keeping sheep with the other stock had an average area of 219 acres, while 358 farms, falling within the same sized limits and similarly organized except for the sheep, had an average area of only 179 acres.

It was found, moreover, as to character of the land area, that these larger farms with sheep have, for the most part, practically the same acreage in crops as farms without sheep, but a relatively higher percentage of pasture and woodland, resulting in a lower land value per acre. Land values on farms on which sheep were found in all three States averaged $25 per acre, whereas the average value on the small farms without sheep was $29 per acre.[2]

HOW THE BUSINESS IS CONDUCTED.

For the year 1914, 30 per cent of the receipts from sheep on the 137 farms studied were derived from the sale of wool; 62 per cent from lambs, and the remaining 8 per cent from the sale of old ewes and increase in inventory value above purchases. At present-day prices with the same production (1917), the receipts from wool would increase to about 40 per cent of the total and those from lambs and ewes decrease proportionately, since the price of wool has increased more rapidly than that of mutton. These figures give an idea of the kind of business carried on. Practically all breeders included in the study were producing spring lambs which were marketed in the late summer or fall at the age of 5 or 6 months, though an occasional breeder was supplying a special trade with fall or early winter lambs marketed in the spring. Practically all sheep were grades, the medium-wool " down " breeds being the most common, though some of the flocks were badly mixed and, as their owners said, they kept "just sheep."

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[1] The few flocks previously referred to as being kept by small farmers were kept on farms of this size.

[2] Only from one-fourth to one-third of the land area of New England farms is suitable for cultivation.

REPLACEMENT AND DEPRECIATION.

The transactions and changes affecting the 137 flocks of sheep give an idea of the depreciation, and of the replacement necessary in order to maintain a flock of sheep in a normal year when little disease occurs. Of all the sheep on the 137 farms at the beginning of the year (Apr. 1, 1914) 10.9 per cent were sold as old sheep, 4.4 per cent died, and 0.8 of 1 per cent were slaughtered, making a total of 16.1 per cent, nearly 1 sheep in every 6, which were either disposed of or died during the year. Of the sheep in the flocks at the end of the year (Mar. 31, 1915) 11.3 per cent were yearlings (lambs of the previous year), while 3.4 per cent were purchased, the total replacement being slightly less than the sales and casualties and resulting in a slightly decreased inventory.

These figures, which are believed to be representative for a year in which little disease occurs, show that in order to maintain a flock of sheep without any decrease in number, it is necessary to replace about one-sixth of the flock each year and that, except for the rams, this replacement consists largely of lambs raised on the place. A loss by death of slightly less than one sheep in 20 can be normally expected, while slightly more than one lamb in 20 dies after having made considerable growth, to say nothing of the deaths occurring at and shortly after birth.

PRODUCTION AND PRICES.

As to production in 1914, each sheep sheared an average of 6.5 pounds of wool, and 75 lambs were raised for every 100 sheep kept.[1] Eleven of the 75 lambs raised were retained in the flock to replace old ewes, leaving only 64 lambs to be marketed for every 100 sheep kept. In addition to the receipts from the sale of wool and lambs, an average of 11 old ewes were sold for every 100 sheep kept.

The average price received for wool was 22 cents, and lambs at that time brought from 6 cents to 6½ cents per pound, live weight, averaging $4.63 each for all sold. The average inventory price for mature sheep at the beginning of the year, April 1, 1914, was $5.24, and $5.50 at the end of the year, March 31, 1915. Discarded ewes were sold at an average price of $4.10 each, while $7.04 was the average price paid for sheep purchased, which were mostly bucks.

THE PROFITABLENESS OF SHEEP AS COMPARED WITH DAIRY CATTLE PRIOR TO 1916.[2]

THE ANIMAL UNIT AS A BASIS OF COMPARISON.

In order to compare the relative returns from the various kinds of live stock some standard of comparision has to be adopted, and to this end use has been made of what is termed an animal unit. An animal unit as here used is a standard unit to which all classes of stock are reduced for means of comparison, and is based upon the amount of feed required by each class of animals when kept under usual farm conditions. It has been found that 1 mature horse or cow, 2 head of young cattle, 7 sheep, or 5 hogs consume in the course of a year approximately the same amounts of feed, hence those numbers[1] for the classes of stock given are taken as constituting one animal unit.

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[1] This number probably included about 10 yearling ewes which had no lambs, and in addition to the 75 lambs raised, 4 died after having made considerable growth, so that the lambing rate for the ewes bred was nearer 88 per cent than 75 per cent.

[2] While the study is based on figures pertaining to the 1914 business year, prices of sheep products did not change materially until 1916, so that the figures apply to the year 1915 as well as 1914.

In the discussion to follow an animal unit of sheep may be thought of as 7 ewes (6 of breeding age and 1 yearling) in addition to their lambs raised to the age of 5 or 6 months. An animal unit of dairy stock in a similar way consists in part of young cattle as well as mature animals, and it is the animal unit of dairy stock rather than a single cow that should be kept in mind in the following pages.

RECEIPTS FROM THE TWO ENTERPRISES.

With prices and production as previously given, the average receipts per head of sheep kept (yearlings included) were $4.78.[2] At this rate, assuming 7 head of sheep equivalent to an animal unit, the receipts per animal unit of sheep under prices and production prior to 1916 were $33.46. The receipts[3] per animal unit of dairy stock, on the other hand, were $67.12, not including $8.40, the estimated value of unmarketed skim milk which could have been sold at 40 cents per hundred weight,[4] making a total of $75.52.

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[1] While the numbers given hold in a general way, adjustment has sometimes to be made to meet the varying breeds and conditions of different regions under which stock is kept. For example, in the case of sheep, where a considerable portion of the lambs' growth is made on feeds other than their mother's milk, requiring extra feeding of either the lambs or ewes, allowance has to be made, in which case, figured on the basis of mature sheep, the number constituting an animal unit would be somewhat less than seven. After having given this point careful consideration it has been decided that as sheep are kept in New England, most lambs being born in the spring of the year and marketed in the fall, seven ewes (yearlings included), raising what lambs they may, is the right number to use as constituting one animal unit.

[2] Includes the following:

Wool, 6.5 pounds at $0.22	$1.43
Lamb, 64 per 100 sheep at $4.63	2.96
Old ewes and inventory increase	.39
Total per sheep	4.78

[3] The average production of dairy cows in the regions in which sheep were kept and with which the comparison of profits is made was slightly less than 200 pounds of butter fat, or a little less than 5,000 pounds of 4 per cent milk. Cream and butter constituted by far the most important classes of dairy products sold, though some whole milk was marketed on a butter-fat basis. Where cream or butter was sold the skim milk was fed on the place and an estimate of the value of that fed to stock other than the cattle made as contributing to receipts. About 75 per cent of all receipts from the dairy were derived from the sale of milk, butter, or cream, and the remaining 25 per cent from sales of stock. The average price received for butter fat for the year in question was $0.345, and butter sold at a proportionate price.

[4] The average price paid for skim milk in 1914 by creameries in the localities studied, in addition to that paid for butter fat included when buying whole milk.

COSTS.

While the data furnished by the survey study are not complete enough to make possible a detailed study of the cost of conducting either the sheep or the dairy industry, taken with other data obtained for the purpose it is sufficiently complete to give a fair indication of the major expense items which are of most concern to the average farmer and have the most pronounced bearing upon profits. Hence the discussion of costs to follow, which is admitted to be incomplete, is presented only as an intermediate step in determining relative profits of the two industries.

Figures available representing the average value of feed consumed per animal unit by all stock on farms with and without sheep, indicate that an animal unit of sheep and dairy stock in New England each consume in the course of a year practically the same amount of roughage other than pasture, but that the dairy stock require many times more grain than do the sheep. As nearly as can be estimated from the data at hand, the total average feed cost per animal unit of sheep above pasture for the year 1914 was $32.20.[1] The estimated feed cost per animal unit of dairy stock on the other hand was $48.90.[2]

As to pasture, the value of that furnished the sheep in late summer and not furnished the cows has already been included in the feed cost under the head of supplementary forage crops. Further than this no attempt will be made to estimate the value of pasture, as it is believed that this cost per animal unit is practically the same for either sheep or dairy cattle and that for the purpose of comparing returns it can well be omitted.

Labor, as nearly as can be estimated, cost about $6.30 per animal unit of sheep as compared with $18.45 per animal unit of dairy stock. This allows for 4.2 days of man labor per year per animal unit of sheep and 12.3 days for the dairy stock, the rate in either case being $1.50 per day, which, according to survey figures, was the average prevailing day wage paid in those regions in 1914.

The feed and labor costs together total $38.50 per animal unit of sheep, and $67.35 per animal unit of dairy stock.

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[1] Includes:

Hay, 2 tons, at $11.40	$22.80
Straw and stover, 0.2 ton, at $5	1.00
Roots, 7 bushels, at $0.10	.70
Supplementary forage crops	3.50
Grain feed, 280 pounds, at $1.50 per hundredweight	4.20
	32.20

[2] Includes:

Hay, 2 tons, at $11.40	$22.80
Straw and stover, 0.2 ton, at $5	1.10
Silage, 1.1 tons, at $3.75	4.10
Grain feed, 1,400 pounds, at $1.50 per hundredweight	21.00
	48.90

RELATIVE PROFITS.

Subtracting the combined feed and labor costs ($38.50 per animal unit for the sheep and $67.35 for the dairy cattle) from the respective receipts[1] ($33.46 and $75.52), it is found that the receipts from sheep lacked about $5 ($5.04) per animal unit of paying for the feed and labor cost, while the dairy stock left a margin of slightly more than $8 ($8.17) over these costs. In other words, if home-grown feeds be charged at farm value,[2] with feeds purchased at cost and labor at the prevailing wage, sheep, under price and production conditions prevailing prior to 1916 scarcely more than paid for the feed consumed during the fall, winter, and spring months (to say nothing of labor, summer pasture, and other costs),[3] while dairy stock paid for both feed and labor and left a margin just about equal to the value of unmarketed skim milk, which would go a considerable way in offsetting the pasture and overhead costs. Had the production of lambs been at the rate of 100 per cent rather than 75 per cent, and the clip of wool been 1 pound greater per sheep, the returns from sheep would have compared much more favorably with those from dairy cattle. It was the opinion of the majority of farmers that sheep were paying better during the period to which the data pertains than formerly. This evidence, together with the figures presented, indicating that dairy cattle were relatively more profitable than sheep for the period just prior to 1916, strongly indicates at least one good reason why the sheep industry declined in the East.

THE RELATIVE PROFITABLENESS OF SHEEP AND DAIRY CATTLE AT PRESENT PRICES.

The figures given above showing relative returns from sheep and dairy cattle are based on prices and production prevailing prior to 1916. From a recent interview the same production still holds, but under present prices, quite another story as to relative profitableness of the two industries would be told. For the present season wool has about trebled in price,[4] while the price of lambs has about doubled. The price received by farmers for dairy products, on the other hand, has increased by about 40 per cent during the same period.[1]

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[1] These receipts include no estimate of the value of manure produced, but it is believed that this is about the same per animal unit of sheep as per animal unit of dairy stock, and that this would in no way change the conclusions as to relative profits of the two kinds of live stock.

[2] Market value less the cost of marketing. In case of hay, less the cost of baling and hauling to market.

[3] Includes interest, use of buildings, and any minor special costs. Depreciation and use of sire, other expense items usually included in the cost of conducting a live-stock enterprise, are eliminated, as with the method employed they are taken account of in figuring receipts; that is, the sire in each case has been included with the rest of the stock in figuring animal units, and the receipts per animal unit represent returns over losses and decreased value of breeding stock.

[4] While a few farmers in New England have received as high as 70 cents per pound for this season's wool, others who sold early received no more than 55 cents, so that it is believed that the bulk of the 1917 clip was sold for no more than 66 cents per pound, which is three times as great as the 1914 price.

As to costs, grains most commonly fed in these regions have increased in price by about 75 per cent;[2] roughage has remained at about the same price (due probably to the large hay crops of the last two years in the regions studied); while labor has increased by about 33⅓ per cent[3] of the former cost.

At present prices, then, assuming the same production from sheep on the one hand and from dairy stock on the other, the gross returns per animal unit of sheep would be $76.93 instead of $33.46, and from the dairy stock $101.37 instead of $75.52. The combined feed and labor costs for the sheep, assuming the same amounts but present prices, would increase from $38.50 to $43.75 and for the dairy stock from $67.35 to $88.65. At these prices the net profit over feed (except pasture) and labor cost per animal unit of sheep are approximately $33.18, as compared with $12.72 from dairy stock, showing that at present, sheep are far more profitable, in small flocks at least, than dairy stock. Prices for sheep products, due no doubt to conditions caused by the war, have increased far more in proportion than have those for dairy products; and furthermore, sheep stand decidedly in favor at present because of requiring relatively little grain feed and labor, the costs of which have increased greatly, while roughage, which forms by far the greatest expense in the cost of keeping sheep, has not increased materially in value—in New England at least.

IMPROVEMENT OF THE SHEEP INDUSTRY.

Though sheep raising as now conducted on the farms studied is a profitable business at present prices, the writer, judging from the experiences of many growers, is convinced that there is much room and great need for the improvement of the sheep industry in New England and that the average grower could, with better care, make the business a much more profitable one, even under normal conditions and without the artificial stimulus to prices given by the war.

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[1] For the two periods of nine months each, ending Aug. 31, 1914, and Aug. 31, 1915, respectively, the Turner Center Creamery, at Auburn, Me., paid an average price of $1.78 per hundredweight for whole milk testing 4 per cent butter fat, while for the same period ending Aug. 31, 1917, the average price paid by the same concern for the same grade of milk was $2.49 per hundredweight, or an increase of practically 40 per cent. A large part of the dairy products in the regions studied in Maine were sold to the concern mentioned, and it is believed that this increase in price of milk is representative of the increase in areas studied in New Hampshire and Vermont as well. A nine months' period instead of a full year was used in making the comparison, as only that length of time up to Sept. 1, 1917, had elapsed since the price of milk had increased materially.

[2] These increases are based on figures obtained at the time the survey was made, together with a knowledge of the prices paid during the past spring and summer. The price paid for grain feed in 1914 was about $30 per ton. An increase of 75 per cent over this amount, to $52.50 per ton, is believed to represent not far from the average price paid for what feed was purchased in the regions studied during a nine months' period ending Aug. 31, 1917.

[3] The average value of labor (farmer's time included) in the regions studied for the year 1914 was about $36 per month, including that part (about one-half) of a man's board not produced on the farm. An increase of 33⅓ per cent, or $48 per month, is believed to cover fully the value of labor spent on the two classes of live stock concerned during the past year.

INCREASING THE LAMBING RATE.

One way of increasing profits is by increasing the lambing rate, which, as will be remembered, was only 75 per cent (on basis of all sheep kept and lambs raised) for the year to which the data pertain. This low rate seems due to three or four reasons, all of which could with better care and closer attention be easily obviated.

In the first place, some breeders are careless about breeding and often fail to get the ram with the flock at the proper time, with the result that many ewes go unbred. Others fail to provide sufficient and suitable feed to keep their stock at all times in good condition, which is as essential at and before breeding time as during pregnancy. Some fail to give the close attention necessary at lambing time, while still others are careless about the selection of breeding stock, keeping in their flocks small, immature ewe lambs (in many cases selling their best ones) and old decrepit ewes which might better have been discarded. It is known that loss results from all these sources and that each contributes toward decreasing the number of lambs born, to say nothing of the deaths that occur at and after birth. Also it is believed that much could be accomplished in the way of increasing the lambing rate through selection, retaining for breeding the offspring of the more prolific ewes that are sure breeders, good milkers, and good mothers.

With closer attention to the factors enumerated it is believed that the lambing rate can be increased so that 100 lambs can be raised per 100 sheep kept rather than 75, as was the case in 1914. In order to attain this standard, assuming a sixth of the flock to be yearling ewes, which in most cases would not be bred, and allowing for a normal death rate of 5 per cent after lambs are started, it will be necessary for every ewe of breeding age to raise at least one lamb and about a quarter of the number to raise a pair. Many of the better breeders are already raising considerably more than this number, and the standard seems a reasonable one to strive for. Such an increase in lambing rate (from 75 to 100 per cent) would allow 25 more lambs to be marketed for every 100 sheep kept, which at present prices would mean an increase in receipts of $2.32 per sheep, or $16.24 per animal unit of sheep.

INCREASING THE CLIP.

The average fleece clipped per sheep in 1914 was only 6.5 pounds. It is believed that by closer selection of stock, eliminating, as before suggested, all small, immature ewe lambs, as well as old ewes, and with better care, that this average could be raised by at least 1 pound, especially where sheep are kept in such small flocks as in New England. Growers agree that sheep well fed and cared for throughout the year shear more wool than do those not well cared for, and it is generally realized that in order to produce a good fleece it is essential to keep a sheep in good condition. They also think that sheep kept in small flocks, probably because of the better care received, produce more wool than when kept in larger flocks, and it is known that some of the growers, even with the mutton breeds, average over 8 pounds of wool per head. An increase of 1 pound of wool per head at present prices means an increase of about 66 cents per sheep, or $4.62 per animal unit of sheep.

EFFECT ON PROFITS.

A one-third increase in lamb production (from 75 to 100 lambs per 100 sheep) and a 15 per cent increase in wool clipped per head (from 6.5 to 7.5 pounds) means, at present prices, an increase in receipts of nearly $3 per sheep, or $20.86 per animal unit. It is not expected that this increased production can be attained without an increase in cost, which, however, would be nowhere near in proportion to the increase in receipts. Allowing for the increased labor and feed believed to be necessary[1] increases the feed and labor cost at present prices from $43.75, the estimated cost with present production, to $50 per animal unit. The estimated receipts being increased from $76.93 to $97.79 as a result of the increased production, leaves a profit over feed and labor cost of $47.79 per animal unit of sheep instead of $33.18, the profit at present production.

In order to do the dairy industry no injustice in making this comparison, an increased production of 20 per cent, or cows producing 6,000 pounds of 4 per cent milk, which is as reasonable an increase as that assumed for the sheep, has been assumed. Allowing for the increased feed necessary[2] with this production increases the cost as estimated at present prices from $88.65 to $99.85 per animal unit. The receipts being increased from $101.37 to $117.60 as a result of increased production leaves a profit over feed and labor cost of $17.75 per animal unit instead of $12.72, the profit at present production.

Increasing the production of the sheep and of the dairy cattle as indicated, while not changing the relative profitableness of the two industries, increases the profits over feed and labor cost in either case by about 40 per cent, making these profits from the sheep business, which it must be remembered is a relatively small industry, $47.79 per animal unit as compared with $17.75 per animal unit of dairy stock.

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[1] In making up this estimate of feed and labor cost necessary for the increased production, allowance for the following increases per 7 sheep (animal unit) were made: Roots, from 7 to 35 bushels; grain feed, from 280 to 350 pounds; labor, from 4.2 to 5 days.

[2] Allows for a slight increase in the amount of silage and increases the amount of grain from 1,400 pounds to 1,800 pounds.

POSSIBILITY FOR EXPANSION.

A considerable expansion of the sheep industry in New England is no doubt justifiable. The above figures and previous ones show that sheep, in small flocks at least, are more profitable than dairy cattle at the present time (1917). It must not be inferred from this that the sheep industry should to any great extent displace the dairy industry, but it is believed that expansion can be made through other channels without decreasing the output of dairy products or disturbing the economics of the region so far as the dairy business is concerned. One's decision to keep sheep must not be based entirely upon the strength of the profit figures shown, as either business is subject to constantly changing prices which at the present time point to a far narrower difference in profits from the two industries than is indicated by the figures given.[1] Also it must be remembered that the figures given are based on records from comparatively small flocks only. Displacing any great number of dairy cows by their full equivalent in sheep means keeping sheep in large numbers, and, as will be shown later, there seems plenty of evidence to support the belief that sheep thus kept in New England are in no wise as profitable as small flocks.

As to channels of expansion, it is known that there are many unprofitable dairy cows in New England and that many of these could probably well be replaced with sheep. However, where poor care on the part of the owner is the main reason for the unprofitableness of the cow, it is likely that sheep would be quite as unprofitable, and before making any replacement the cause of the unprofitableness should in all cases be determined. Some farms are located so far from market as to make their operation as dairy farms impracticable, while other operators have abandoned the dairy business because of the difficulty of securing help. These two classes of farms offer much room for the expansion of the sheep industry and, if rightly managed, there is little doubt that sheep would prove much more profitable than beef cattle, which at present constitute most of the live stock on such farms. Some other farms in addition to the classes mentioned could carry a small flock of sheep in addition to the regular amount of stock, but careful consideration should be given the pasture requirement to make sure that this does not lead to overstocking.

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[1] The price of milk in New England was advanced 1 cent a quart, or about 50 cents per hundredweight, for the months of August and September and the first half of October, while a still further advance of 1 cent a quart was made to be effective from Oct. 15 to Dec. 1, 1917.

CARE OF SHEEP IN NEW ENGLAND.

IMPORTANCE OF GOOD CARE.

Judging from the experiences and observations of the growers included in this study, it would appear that care is the most important factor bearing upon the profitableness of the sheep business in New England, and its bearing upon several sources of loss has already been touched upon. Excepting possibly disease, which is to a large extent avoidable, it is believed that more losses in the sheep business are due to lack of good care and feed than to any other one thing. Although sheep may be said to function to some extent as scavengers—and too many make the mistake of feeding on the assumption that sheep can thrive eating weeds and cleaning up fence rows and wastelands—like any other animals they must have good care if good results are to be expected from them.

The requisites of good care for sheep[1] may be briefly enumerated as follows: Plenty of wholesome feed at all times; dry quarters, good ventilation, and an opportunity to exercise while being stabled; and close attention at lambing time. Occasional inspection and regular dipping is also essential to insure freedom from lice, ticks, and skin diseases.

SUMMER FEEDS.

As to feeds, in most cases sheep in New England require during the summer months nothing but good pasture. In the more favored sections of New England, where natural grazing land (see fig. 2)

FIG. 2.—Sheep grazing on a luxuriant bluegrass pasture in Vermont. Such pastures, which are the exception rather than the rule in New England, do not need to be supplemented with forage crops until late in the season, and sometimes carry the breeding stock through the entire pasture season without supplementary pasture.

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[1] The care of the farm flock is fully discussed in Farmers' Bulletin 840, which is obtainable upon request from the Department of Agriculture.

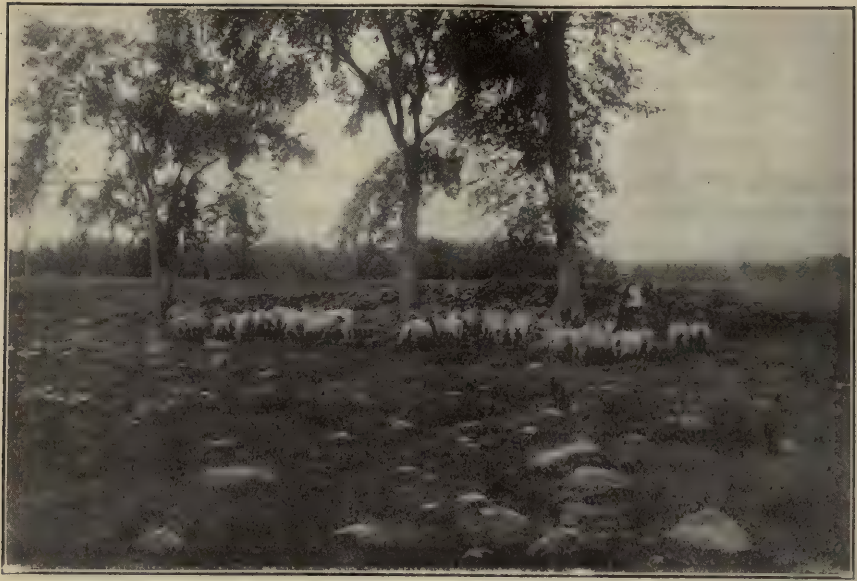

FIG. 3.—A flock scene at salting time. The rough, stony pasture, which is more typical of New England than the one shown in figure 2, affords considerable feed, but has to be supplemented by other feed much sooner. The mistake is often made of leaving sheep on such pastures too late in the season, which is good for neither the sheep nor the pasture.

is to be had, but little other pasture is necessary. In less favored sections, where pastures do not hold out throughout the summer (see fig. 3), other feed should be provided. It has been found impractical in most cases to keep sheep in New England unless pasturage can be depended upon during the entire pasture season, or at least until after the field crops are harvested, when the sheep can be allowed for a time the run of the entire farm. Some make a practice of pasturing sheep with other stock, while others prefer to have them alone. Sheep are known to eat a great variety of herbage, and the majority agree that sheep render a valuable service in keeping down weeds that cows will not eat. On the other hand, it is known that sheep crop much closer than do cows, and it is agreed by the majority that for this reason cows do not do as well, unless the pasturage is luxuriant, when pastured with sheep.

It is especially important that plenty of pasture be provided during the late summer and fall when the lambs need to be put in shape for market and the rest of the flock kept in the best of condition for breeding. At this season of the year the regular pastures usually afford but little feed, and that of an inferior quality, so that it is necessary for good results to make provision for other than the regular pasture. A good practice among many growers is to separate the lambs from the ewes about a month before marketing time, pasturing the lambs on second-growth clover, or in many instances allowing them the run of the entire farm, and keeping the ewes on the old pasture until after the lambs have been turned off, when the ewes also are allowed the run of the farm. This practice works out satisfactorily where extra fencing for the sheep is not necessary and where the old pasture affords sufficient feed to keep the breeding stock in good condition until they can be allowed the run of the place.

A safer practice, which is already being followed by a few of the more successful growers and which is to be highly recommended, is the growing of some forage crop for late summer and early fall pasture. Rape makes an excellent crop for this purpose and is one well adapted to New England conditions. To give best results rape should be sown on good land, loam preferred, which is not subject to drought, since the crop often fails in dry seasons. If raised on weedy land the seed should be sown in drills 30 inches apart at the rate of 1 to 1½ pounds per acre and the plants regularly cultivated, while if on land free from weeds, broadcast seeding at the rate of from 2 to 3 pounds per acre gives satisfactory results. The crop can be grown alone or, if on clean land, with another crop such as oats or rye or following a crop of corn (see fig. 4), in which case the seed is sown broadcast or in drills between the rows of corn at the last cultivation. Where early feed is desired, and the land can

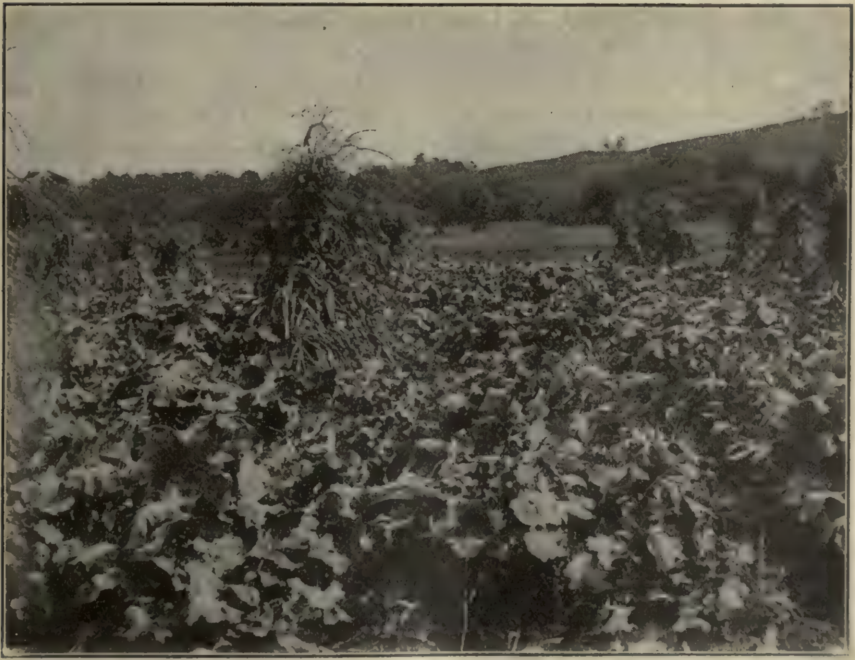

FIG. 4.—Rape grown in corn to be used for fall pasturage in fattening lambs. The seed was sown in the corn at the last cultivation at the rate of 1 pound per acre. Two acres of such feed will normally fatten 40 lambs.

FIG. 5.—Ewes and lambs pasturing on rape, which has been practically all eaten off. This crop, which was sown alone for early fall feeding, was used to supplement the typical New England pasture shown in the background.

be spared, it is probably best to raise the crop alone (see fig. 5), but if the feed is not needed until some little time after corn is normally cut, the latter practice answers the purpose as well. In New England a period of from 8 to 12 weeks should be allowed from the time of sowing the seed until the crop is ready to feed. If sown alone in early May and cultivated, feed should be afforded by the latter part of July, while a seeding in corn from July 1 to 15 ought to provide October and later fall feeding as long as needed, much of the growth being made after the corn is cut. Cultivation induces growth and increases the yield, though the results obtained by seeding corn on good land are very satisfactory.

One acre of the crop grown alone, or 2 acres following corn, is usually sufficient to fatten from 30 to 40 lambs if allowed the run of other fields, as is usually the practice where rape is grown. Care should be taken in regard to bloating, when first turning sheep into a field of rape, but after the first few feeds no trouble need be expected. This crop, if more generally grown would do much toward solving the fall feed question and should be more extensively used where sheep are kept.

WINTER FEEDS.

As to winter feeds, any one of the finer hays makes good forage for sheep. Legumes are to be preferred if not too coarse, coarse hays making poor feeds for sheep. Alsike Clover in particular is to be recommended, while large Mammoth Clover is too coarse. Some make use of this, however, by allowing the sheep to pick it over and eat only what they want, feeding the coarser parts to other stock. "Rowen," as it is known in New England, or the aftermath from hay lands, is said to make an excellent feed for sheep, and many plan to save their rowen to feed the sheep just prior to and at lambing time. Redtop, fine lowland hay, and what is known locally in many places as June grass, all make good sheep hays, whereas "Herds Grass" (timothy), millet, and other coarse hays are not to be desired.

In addition to dry roughage, some form of succulent feed should be provided. This form of feed is too often lacking; but it is particularly essential in keeping sheep in good condition during the winter, and if fed with the right kind of hays probably reduces considerably the amount of grain required. For New England, probably nothing is better than rutabaga turnips (see fig. 6) for this class of feed. Sweet apples are sometimes fed in the place of or to supplement roots, with good results. Corn silage is available on many farms and could be used as a succulent feed for sheep much more extensively than it is.

Practically the only grain fed to the farm flock in New England is fed just prior to and at lambing time, and most growers agree that some grain at that time is essential. Whole or ground oats and wheat bran, sometimes with a little oil meal, is the grain mixture

FIG. 6.—A crop of rutabaga turnips grown to feed sheep. This form of succulent feed should be more generally used as a part of the regular winter ration for sheep. The topography and vegetation of the pasture in the background is typical of much New England land.

most commonly used. The amount of grain needed seems to depend much upon the other feeds available and to some extent upon the season. If plenty of the finer varieties of hay, particularly clover, has been used, together with succulent feeds in the form of roots or silage, but little grain is needed. On the other hand, if the roughage has consisted largely of coarse, inferior hay, and little or no succulent feed, grain needs to be fed in much larger quantities and for a much longer period. As a general thing it will not pay to keep sheep unless the hays cited as best adapted to their needs can be grown together with some form of succulent feed. Some growers feed no grain at all, but the better ones make a practice of graining for a time, from 4 to 6 weeks in the spring of the year before turning out to pasture, and without doubt it is feed well worth while. The principal thing is to keep the flock in good condition at all seasons of the year, and in order to do this some grain is usually essential for at least a month in the spring of the year, especially if the lambs come before the ewes go on grass.

FRESH AIR AND EXERCISE.

It is known that these two factors of care, which have so direct an effect upon the health of sheep, are too often ignored, and their importance can not be overemphasized. Elaborate and expensive ventilating devices or buildings[1] are not necessary, the main principle to be observed in making provision for ventilation being to make sure that fresh air is to be had at all times without exposing the flock to drafts. The pens should be roomy, at all times dry, and the sheep should be allowed a chance to get out of doors during the day. If necessary to induce exercise, a part of the feed can be scattered out of doors on the snow, but at no time should sheep be exposed to driving snow storms or drenching rains.

ATTENTION IN THE SPRING.

Sheep require relatively little time as compared with other kinds of stock, but attention at certain times is important. At lambing time sheep require close attention, the importance of which is well expressed in Farmers' Bulletin 840, page 14, in the following statement: "The lambing season is the shepherd's harvest time, and the size and quality of the crop practically determine the profits * * *. At this time extra attention must be given to the ewes and lambs. In no other way can time be used to better advantage on the farm." The sort of attention necessary at this season is fully discussed in the bulletin referred to, while the respective advantages of early and late lambing will be discussed later.

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[1] Equipment and building construction for farm sheep raising are fully discussed in Farmers' Bulletin 810, which is obtainable from the Department of Agriculture upon request.

Dipping the sheep, docking and castrating the lambs, etc., are also fully discussed in Farmers' Bulletin 840, pages 14 to 18. Regularity of practice in these regards is an essential factor bearing upon success with sheep.

ADVERSE FACTORS.

DISEASES.

Of the difficulties encountered in sheep raising in New England it is believed that the disease factor is the most important. While but little disease occurred during the year the study was made, taking the sheep-raising sections of New England as a whole, year in and year out, it is known that much loss results through disease. Some growers have but little trouble in this respect, especially those who are careful about selection, feed well, provide sanitary quarters, and keep their flocks in the prime of condition throughout the season, while others report large losses, at times as high as 50 per cent of their entire flocks. (Several such instances were reported during the spring of 1917.)

It is not the purpose of this bulletin to tell how to treat the various diseases to which sheep are subject, but attention is called to those which have most frequently to be contended with, and anyone keeping sheep is advised to acquaint himself with the symptoms and treatment of each. It is believed that much loss can thus be averted.

Stomach worms,[1] grub in the head, nodular disease of the intestines, and indigestion are the troubles most frequently reported in New England and seem to be the ones to which most loss is due. Skin diseases and ticks[2] are also important and give considerable trouble unless regular dipping is practiced.

Much complaint is heard of flocks running out or degenerating, and many breeders say that they have to sell out and start their flocks anew at intervals of every 8 or 10 years. It is believed that a great deal of the running out of flocks is due as much to worm trouble, which is not recognized as such in many cases, as to anything else. A change of pasture at intervals of every 10 days or two weeks is recommended as a safeguard against worm trouble, though this is not always practicable as New England pastures are located. It is likely that much more could be done in combating this disease by making more extensive use of aftermaths and forage crops in supplementing the regular pastures. As prevention of infection is the most practical means of handling this trouble, it is important that the breeder inform himself of the method outlined in Farmers' Bulletin 840 in order to be better enabled to cope with it.

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[1] Farmers' Bulletin 840, p. 20; also Bureau of Animal Industry circular (Zoological Division) entitled "How to prepare and administer the bluestone or copper sulphate dosage in the treatment for stomach worms."

[2] "Sheep scab" is fully discussed in Farmers' Bulletin 713 and the "Sheep tick" in Farmers' Bulletin 798, either of which is obtainable upon request from the Department of Agriculture.

A few growers, who already have regular pastures so located as to permit shifting, recognize the advantages of changing pasture and make a practice of changing their flocks from one pasture to another, and sometimes to a third, during the same season, and though in most cases they can give no good reason for their success, they claim to get better results by so doing. Since the length of time on each pasture is much greater than two weeks (the maximum time a pasture can be occupied and insure safety from infection), it is likely that the advantage gained in this respect is due to the better feed afforded rather than to the prevention of worms, yet the practice is a good one and should be more generally followed.

The appearance of some flocks brought under the writer's observation, and their histories as told by the owners, lead to the conclusion that most of the so-called running out not due to disease can be attributed to poor care and to degeneration as a result of long-continued inbreeding. Inbreeding to any great extent should be avoided and new blood introduced occasionally in order to maintain vigor and vitality.

The disease factor is one which can hardly be overemphasized. It appears to be one of the most important factors, probably much more so at present than the dog question, in the development and profitableness of the sheep industry of New England.

THE DOG QUESTION.

What has many times been set forth as one of the greatest obstacles to sheep raising in New England is the dog. Loss from canine depredation is considerable, and it is sometimes claimed that the dog[1] was responsible for the decline in sheep raising in the eastern portions of the country. From the figures heretofore given, showing the profits under former prices, together with investigation in respect to this particular question, it would appear that other factors, particularly disease, low prices, and the development of cheaper grazing lands in the West, were each quite as potent as the dog in this regard.

It must not be inferred from this that the dog question is to be ignored. It is still a serious one, and one that calls for further remedial legislation, in some States at least. There is, however, a marked improvement in public sentiment and good prospect that sheep growers will get additional protection in this regard.

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[1] The question of the sheep-killing dog is fully discussed in Farmers' Bulletin 935, which is obtainable from the Department of Agriculture upon request.

Wild animals, particularly bears, are said to be quite as great a menace as the dog in some of the more remote regions, but such conditions are rare.

SIZE OF FLOCK.

Since in New England, with but few exceptions, sheep are kept in small flocks[1] only, the question naturally arises: Are sheep so kept because large flocks are unprofitable? Practically all the farmers interviewed agreed that sheep do better in small flocks, and while some could give no good reason for their belief, others were of the opinion that the better results obtained from small flocks were due to the better care received by each individual. The same principle as regards the strong and weak applies with sheep as with other animals, and it is a great mistake to put weak, immature sheep or old ewes in with a lot of strong individuals and expect all to do well.

Probably one reason why large flocks have not done better in England lies in the limited housing space available on the average farm. Most farms on which cattle are kept have housing space for a small flock only, and all growers agree that sheep should not be crowded. Not only is the wool clipped per head likely to be less when the sheep are kept in crowded quarters, but also the chance for disease, ticks, and improper nourishment is greatly increased. Sheep need, in addition to wholesome feed, plenty of room, a chance to exercise, and good ventilation, none of which can be had in crowded quarters. Some farmers keeping no more than 40 ewes separated them into two flocks, during both summer and winter, saying that they obtained better results by so doing. It may be that in these cases housing space was so arranged as to accommodate only 20 head in one flock, but in the light of the experience of others, it is believed that as many as 40 sheep, and probably a few more, can be safely handled in one flock, provided all are good strong individuals, housing space is adequate, and feed and pasturage plentiful.

Farmers' Bulletin 840 points out that at least 30 ewes, or, better still, 60 or more, can be much more economically handled than a very small flock, and that because of its being a much more important part of the farm business the large flock is likely to receive more attention and better care than the very small one.

In a few instances large flocks of sheep are being kept in New England with good success, but these cases are the exception rather than the rule, and occur where practically the entire business of the farm is caring for sheep. One of the largest breeders in New Hampshire keeps on an average from 225 to 250 breeding ewes, keeping them both summer and winter in three separate flocks. Where close attention can be given, such as these flocks receive, results from large flocks are satisfactory, but such flocks are not to be recommended for the general farmer, who has not the time to devote to giving them the close attention required.

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[1] In this discussion the term "small flock" includes numbers up to 40 or 50 head.

While it is no doubt possible, under certain conditions, especially at present prices, to make sheep in large flocks pay, it is more than likely that the small flock—consisting of from 20 to 50 head, depending upon housing space and available summer pasture—kept in conjunction with dairy cattle as a general farm proposition, is the most desirable flock for New England. The figures given show that, with but few exceptions, sheep are kept in practically no other way; the experiences of growers lead to the same conclusion, and farmers themselves are of the same opinion.

QUESTIONS OF BREEDS AND BREEDING.

Sheep of the middle-wooled "down" breeds are the most numerous in New England, and of these the Shropshire and Hampshire are probably the most common. Dorsets and Cheviots are important in some regions, and other breeds to a less extent. Traces of Merino blood are also to be found in some flocks, especially among the older flocks, whose owners were in the business when the production of wool was the main reason for keeping sheep. Most of the flocks are "grades," the better breeders keeping pure-bred rams and grading up their flocks to some particular breed, while in a few flocks, whose owners say they keep "just sheep," it is difficult to detect the marks of any particular breed.

As to the comparative merits of the different breeds[1] there is great diversity of opinion. All agree that the "down" breeds are more easily handled in regard to fencing, but it is claimed that some of these breeds are less hardy and do not withstand the rigorous New England climate as well as some other breeds. Any number of instances are known, however, where the breeds condemned for this reason are being kept with good success, so that something other than the breed is evidently at fault with those who claim poor success. The Cheviots, on the other hand, are noted for their hardiness, and some prefer to cross in with the Cheviots in order to secure this hardiness, while the same advantage is claimed for the Merinos by those who still have that blood. Dorset crosses are kept where early lambing qualities are desired.

For a general farm proposition New England needs a dual-purpose sheep that will produce a good heavy lamb in a reasonably short time and grow a good fleece of wool in addition. The middle-wooled mutton breeds seem to come the nearest to fulfilling these requirements, and it is known that these breeds do well if careful selection of breeding stock is practiced and good care given at all times. Within this class it is a matter of choosing one's favorite breed, picking out good strong ewes each year and occasionally introducing new blood, preferably of the same breed. Crosses do well in some instances, but the promiscuous mixing of breeds is in nowise to be recommended, and under usual circumstances it is the best practice to stick to the same breed, aiming at all times to keep none but strong, healthy stock.

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[1] Fully discussed in Farmers' Bulletin 576, to be obtained from the Department of Agriculture upon request.

EARLY VERSUS LATE LAMBS.

As to the best time to have lambs come, whether early or late spring, there is great diversity of opinion, and numerous growers can be found who are following each method, apparently with equally good results. Either method has its advantages and disadvantages, and which practice one should follow depends to a large extent upon market demands and the facilities of individual breeders for handling sheep. Early lambs are said to be less subject to attacks of parasites[1] than are late lambs, which is a very important factor where stomach worms have given trouble. It is claimed by those who have their lambs come early that by getting an earlier start they make larger lambs, which can be turned off earlier than when they come later. It is also pointed out that early lambing permits of dipping, docking, and castrating before the lambs are turned away to pasture, important operations which are likely to go undone if the lambs do not come until the ewes have gone on grass.

Those who have their lambs come late claim, on the other hand, a great saving in expense for grain, the lambs requiring no grain and the ewes but little as compared with that fed to both for a long period under the other method. With this method it is said that scarcely any trouble is experienced with ewes not having milk and disowning their lambs, a trouble which occurs to a considerable extent where lambs are dropped early. Also with late lambs less attention is required at lambing time, and it is claimed that if pastures are good and the season not cold the lambs begin to grow at once and make a much better and quicker growth than where the lambs come earlier.

From the writer's observations, while late-dropped lambs may make a quicker growth, in regions where this method is practiced lambs are not marketed until a month or so later than in other regions, and where the market demands summer and early fall lambs, it is doubtful if late lambs will make a profitable growth.

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[1] Farmers' Bulletin 840, p. 22.

BREEDING YOUNG EWES.

While many young ewes are bred to lamb at yearling age, the advisability of the practice as a general one is questionable. Many breeders are of the opinion that the growth of the average ewe lamb is greatly impaired if she is bred to lamb at yearling age, and that, while many young ewes can be bred to lamb at that age, small stock will result if this practice is followed. Others, however, say that if their lambs have been born early in the spring and have made good growth, the ewe can be bred to lamb at one year of age with no evil results. The writer knows of a few breeders who take exceptionally good care of their flocks and raise strong early lambs, and who are following this practice with apparently good success. It is likely, however, that the practice is not to be recommended for the average grower, whose lambs are born none too early in the spring to make the growth essential, and that an increased lambing rate can better be achieved by other means.

SINGLE VERSUS TWIN LAMBS.

In the preceding pages it has been shown that in order to increase the lambing rate to 100 per cent on the farms studied about one-fourth of the breeding ewes must raise twin lambs. Many growers prefer to have their ewes raise but one lamb, saying, in most cases, that "one good lamb is better than two poor ones," but here again it seems a matter of care more than anything else, and the best breeders see no objection to a good strong ewe raising a pair of lambs, nor do they think that twin lambs are likely to be much smaller than those dropped singly. They prefer, in most cases, to have young ewes and old ewes raise but one lamb each, but do not object to strong medium-aged ewes having more than one lamb. The more successful growers aim to get as many lambs as possible, and one of the best ways of increasing the lambing rate seems to be by selecting along this line.

SHEEP ON LARGE RANGES.

The writer's attention has been called to a couple of large ranges; one, embracing upward of 4,000 acres, a large part of which affords fair grazing, being cited as a possibility for a large sheep proposition; the other, which was said to carry 500 or 600 sheep, as a striking example of failure due, as nearly as could be determined, to disease and lack of care. One drawback to the first proposition, and without doubt to others of its sort, was its lack of tillable land, or at least enough of such land on which to grow the necessary forage for wintering the breeding stock. This difficulty could perhaps be obviated by operating the range in conjunction with tillable farm land in the same or other localities, utilizing the range as pasture during the summer and housing the breeding stock during the winter on the farms growing the forage. Such a proposition should be carefully considered from all angles, however, before making the venture, and especially in reference to suitable feeds and trouble from disease. These two factors are of vital importance with the small flock, but their importance is magnified many fold when it comes to keeping sheep in large numbers. The small farm flock can be handled in connection with other stock with but little trouble, and, if well cared for, under present prices at least, it is a valuable asset to its owner. The large flock, on the other hand, calls for close attention, and requires the services of a shepherd who thoroughly understands his business if success is to be expected.

PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE RELATING TO SHEEP RAISING.

PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT OF AGRICULTURE.

Breeds of Sheep for the Farm. (Farmers' Bulletin No. 576.)

Sheep Scab. (Farmers' Bulletin No. 713.)

The Sheep Tick and Its Eradication by Dipping. (Farmers' Bulletin No. 798.)

Equipment for Farm Sheep Raising. (Farmers' Bulletin No. 810.)

Farm Sheep Raising for Beginners. (Farmers' Bulletin No. 840.)

The Sheep Killing Dog. (Farmers' Bulletin No. 935.)

The Woolgrower and the Wool Trade. (Department Bulletin No. 206.)

The Chemical Composition of Lime-Sulphur Animal Dips. (Department Bulletin No. 451.)

The Use of Energy Values in the Computation of Rations for Farm Animals. (Department Bulletin No. 459.)

Suggestions from Australasia to American Sheep Raisers. (Separate 645 from Year Book 1914.)

Karakul Sheep. (Separate 673 from Year Book 1915.)

PUBLICATIONS FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Sheep Killing Dog. (Farmers' Bulletin No. 652.) Price, 5 cents.

Management of Sheep on the Farm. (Department Bulletin No. 20.) Price, 10 cents.

Domestic Breeds of American Sheep. (Department Bulletin No. 94.) Price, 25 cents.

Features of the Sheep Industries of the United States, New Zealand, and Australia, Compared. (Department Bulletin No. 313.) Price, 10 cents.

Experiments in Vaccination Against Anthrax. (Department Bulletin No. 340.) Price, 5 cents.

Larkspur Poisoning of Live Stock. (Department Bulletin No. 365.) Price, 25 cents.

Grazing Industry of the Blue-Grass Region. (Department Bulletin No. 397.) Price, 5 cents.

Sheep Scab, Its Nature and Treatment. (Bureau of Animal Industry Bulletin No. 21.) Price, 15 cents.

Prevention of Losses Among Sheep from Stomach Worms, Haemonchus Contortus. (Bureau Animal Industry Circular No. 157.) Price, 5 cents.

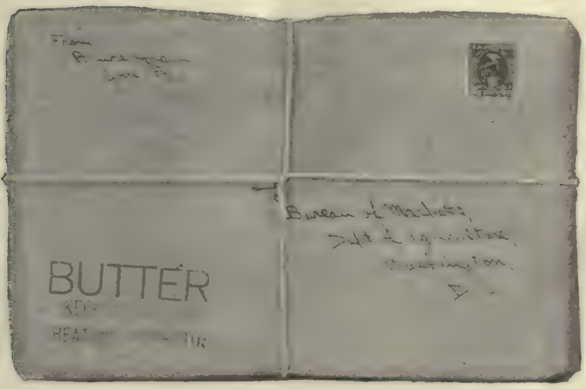
Pasturage System for Handling Range Sheep. Investigations during 1909. (Forestry Circular No. 178.) Price, 5 cents.

Special Report on History and Present Conditions of Sheep Industry. (Bureau of Animal Industry.) Price, $1.40.

MARKETING BUTTER AND CHEESE BY PARCEL POST

LEWIS B. FLOHR
Investigator in Marketing, and

ROY C. POTTS
Specialist in Marketing Dairy Products



FARMERS' BULLETIN 930

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Markets
CHARLES J. BRAND, Chief

Washington, D. C. May, 1918

Show this bulletin to a neighbor. Additional copies may be obtained free from the Division of Publications, United States Department of Agriculture

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1918

BECAUSE BUTTER does not keep well unless good storage facilities are available, most families must purchase it frequently and in small quantities.

Parcel post has been found a desirable and useful means of sending butter from producer to consumer, and when favorable conditions exist and proper methods are used in preparing and mailing, it carries satisfactorily by that method of transportation.

There are practically no difficulties in transporting cheese by parcel post. Frequently this method of marketing affords an economical and satisfactory way for obtaining cheese for family use.

MARKETING BUTTER AND CHEESE BY PARCEL POST.

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BUTTER is highly perishable unless it is handled under proper conditions, yet the fact that many consumers obtain their supplies direct from producers by parcel post, proved by the quantity passing through many post offices, indicates that parcel-post marketing of butter is feasible. It is usually an economical method, as the cost of market distribution through the regular wholesale and retail channels of trade is relatively high in comparison with the cost of shipments by parcel post from the first and second and sometimes more distant zones.

EXPERIMENTAL PARCEL-POST SHIPMENTS OF BUTTER.

Shipments of butter aggregating more than 10,000 pounds have been made by the Bureau of Markets, under various conditions and in packages carrying from 1 to 10 pounds, over both long and short distances, in order to test various kinds of shipping containers, methods of packing, and the possibilities of parcel-post shipping of butter during the summer and other seasons. These experimental shipments consisted of (1) shipments of fresh butter from four creameries to this bureau, and (2) shipments of the butter received from the creameries by the bureau to experiment stations and return shipments of the same. The summarized results of the shipments from the four creameries are presented in the following table:

TABLE I.—*Experimental shipments of butter by parcel post in 2, 3, 5, and 10 pound parcels from creameries to the Bureau of Markets.*

Creamery.	Distance from Washington (miles).	Hours in transit.	Months covered.	Number of shipments.	Received in satisfactory condition.		Received in unsatisfactory condition.		Total pounds of butter.
					Number.	Per cent.	Number.	Per cent.	
A	375	22	April to October	222	218	98.2	4	1.8	822
B	536	48 to 60	August and September	61	60	98.4	1	1.6	249
C	187	18 to 20	June and July	82	73	89.0	9	11.0	290
D	206	18 to 20	April to January	89	89	100.0	......	......	661
Total				454	440	96.9	14	3.1	2,022

Although many of these shipments were made during the heat of summer, only 14 of the 454 shipments, or 3.1 per cent, were received in an unsatisfactory condition. These very satisfactory results may be attributed to the care exercised in the proper packing of the butter in suitable shipping containers and the precooling or thorough hardening of the butter at the creameries before shipment.

The experimental shipments to the State experiment stations were satisfactory where the temperature and distance were not too great. Butter which had softened much in transit from the creamery to the bureau when later shipped to the experiment stations did not arrive in as good condition as that in which the grain had not been previously injured. In general, the shipments from Washington were successful when forwarded as far north as Maine and as far west as Michigan and Indiana. Shipments into the South were successful for shorter distances.

The results of these experimental shipments indicate that well-made butter, thoroughly chilled before shipping, when packed in a suitable container, may be marketed satisfactorily by parcel post when extreme high temperatures are not encountered. Under ordinary conditions, where the butter does not melt and a firm or semifirm condition is maintained, the shipping of butter by parcel post generally may be successful. Even though proper safeguards were taken, the shipments made during extremely hot weather frequently arrived in an oily and unsatisfactory condition.

QUALITY AND CONDITION OF BUTTER.

As parcel-post shipments of butter are likely to be subjected to conditions, especially during the summer, which may cause deterioration and injure the quality of the butter, it is highly desirable that every possible precaution be taken before shipment. Particularly is this true of farm-made butter, because conditions affecting its quality and condition usually can not be controlled as easily on farms as in creameries. However, farm-made butter should be marketed just as satisfactorily as creamery-made butter when it is properly made and prepared for shipment.[1]

It is necessary to maintain proper conditions in the care of the milk and cream and the making of butter if a marketable product is to be produced. Too much importance can not be given to the maintaining of cleanly conditions in the stable and in other places where the milk, cream, or butter are produced or kept, for they absorb odors and spoil very quickly. It is important, too, that these products be kept in a cool place. High temperatures should always be avoided, as heated cream or butter produces a soft, oily condition in the finished product which is undesirable. In manufacturing butter on the farm or in a factory the buttermilk must be removed and washed out, and the proper amount of salt must be incorporated evenly. Frequently parcel-post shipments of farm butter are unsatisfactory to customers because proper methods were not used in making it, and thereby the quality and condition of the butter were injured before it was shipped. For the satisfaction of customers it is important that a uniform quality of butter be produced.

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[1] Those desiring information on making farm butter may secure, upon request to the Division of Publications of the United States Department of Agriculture, a copy of Farmers' Bulletin No. 876, entitled "Making Butter on the Farm."

PREPARATION OF BUTTER FOR PARCEL-POST SHIPPING.

The methods used in preparing butter for parcel-post shipping depend largely upon the local conditions and the style of package used. To insure delivery in the best possible condition, butter, after being packed or printed and placed in cartons, should be chilled or hardened thoroughly before it is shipped.

One of the most satisfactory ways of preparing butter for shipment is in the form of regular 1-pound prints. The standard print measures 2½ by 2½ by 4⅝ inches. A hand butter printer or mold should be used in forming the prints. The printer shown in figure 1 is so made that it can be taken apart readily and thoroughly cleaned. The print of butter is easily removed from the mold by the false bottom. Another style is made with the sides and ends hinged to the bottom and held in place by hooks across the ends. After the butter is packed in the mold the sides are unhooked, so that the butter can be removed from the printer. One-pound hand printers similar to these styles may be secured from dairy-supply companies or they may be made on the farm.

Each pound print should be neatly wrapped in regular butter parchment or paper. A second thickness of such paper has been found to add materially to the carrying possibility of the butter. Waxed paper may be used for the second wrapping. As a further protection to the print, it should be placed in heavy manila paraffined cartons, which may be obtained from folding paper-box companies for about one-half cent each when unprinted or at a slightly additional cost when printed as a stock carton or with a special private brand.

SHIPPING CONTAINERS FOR BUTTER.

Corrugated fiber board shipping containers of various sizes may be obtained for shipping 1-pound prints of butter. (See fig. 2.)

These boxes or containers practically insulate the butter and furnish much protection against heat. Further protection may be obtained by wrapping the container in stout wrapping paper. The whole should be tied securely with a strong cord. In tying the twine, it should be drawn tightly around the package so as to insure its proper carriage. Not infrequently packages are broken open or otherwise damaged because they are insecurely tied. The corrugated containers are also useful for carrying shipments of butter put up in other styles.

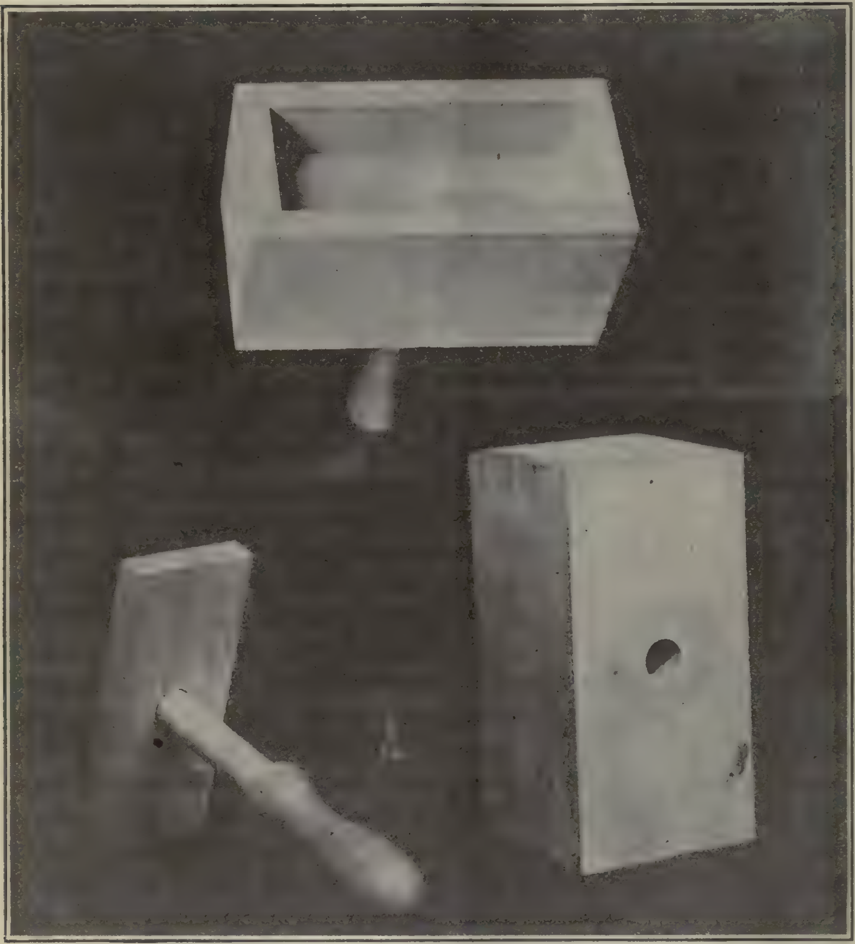

FIG. 1.—Two views of hand printer for 1-pound prints.

Some persons ship butter by parcel post in improvised or "homemade" containers. Clean, discarded, corrugated paper-board cartons are obtained from the grocer or other merchant at small cost or frequently without cost. It is possible to cut a piece of paper board in such shape and size that when it is folded it will form a satisfactory carton. In figure 3 is shown a piece of paper board that is cut so as to provide a carton for shipping 3 pounds of butter that is wrapped in parchment paper and several thicknesses of newspaper.

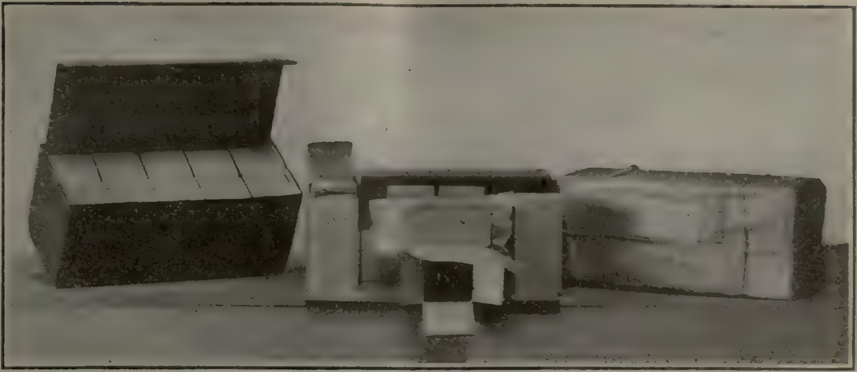

FIG. 2.—Three stages of a parcel-post package of butter: Wrapped, opened, showing print of butter.

For this carton the paper board was so cut that it was 7½ inches wide and 25 inches long with projections in the middle of the length which were 4½ inches wide and extended 8½ inches on each side. This provided a carton with dimensions, when folded, as shown in the illustration, of 4½ by 6 by 7½ inches.

Butter shipped in an improvised container should be wrapped in parchment paper and several thicknesses of newspaper and then should be securely tied with string. The package should then be inclosed in the piece of corrugated paper board with the projections of the paper board so folded as to form a container. The container

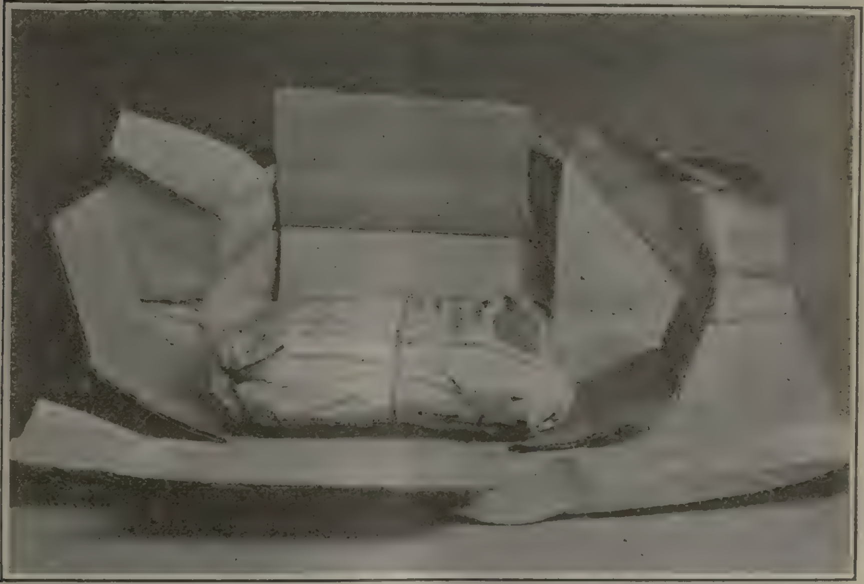

FIG. 3.—Actual parcel-post shipment of 3 pounds of butter wrapped in parchment paper, several thicknesses of newspaper, corrugated paper-board carton, and finally an outside wrapper of heavy wrapping paper.

should then be tied with twine, wrapped in heavy wrapping paper, and again tied securely with a strong twine.

If butter that is prepared for shipment in this manner is thoroughly chilled before being mailed, it should carry safely even in warm weather if it is not in transit over 24 to 36 hours.

EXAMPLES OF SUCCESSFUL MARKETING OF BUTTER BY PARCEL POST.

A few of the many instances which have come to the attention of the bureau will indicate with what success butter may be marketed by parcel post.

A farmer's wife who was making a good quality of butter was securing but little more than half retail price a pound for it when a trial shipment was made by parcel post to a consumer in a large city.[1] As the result of this shipment, a demand was developed and customers obtained for the entire product at an advance in price to the farmer's wife and with a considerable saving to the customers under the retail price of the best creamery butter.

A number of creameries have developed an extensive parcel-post business. One which has a large output markets practically its entire product direct to consumers or retail distributers, except in the flush of production in spring and early summer. Another has developed a substantial parcel-post trade by sending out a weekly price list. Formerly this creamery used newspaper advertisements, but the manager says that the quality of the butter is sufficient advertisement.

ESSENTIALS FOR SUCCESS IN MARKETING BUTTER BY PARCEL POST.

Successful parcel-post marketing of butter requires that extreme care be taken to insure the delivery of a satisfactory product to the customers. The following are a few of the important considerations to be observed to market butter successfully by parcel post:

1. A uniformly high-quality product should be produced.
2. It should be properly packed in neat and attractive packages.
3. The shipping container used should amply protect the butter from deterioration and damage.
4. The packages should bear the address of the sender and be properly addressed to the customer.
5. The most expeditious mail service from the mailing office should be used to insure the delivery of the butter in the best condition.

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[1] Those desiring to obtain suggestions regarding parcel-post business methods should make request to the United States Department of Agriculture for a copy of Farmers' Bulletin No. 922, entitled "Parcel-Post Business Methods."

VARIETIES AND STYLES OF CHEESE.

Most varieties of cheese, being firm and not so subject to damage by high temperature as butter, may be shipped any distance by parcel post without difficulty. (See fig. 4.)

The two important varieties of cheese produced on farms are cottage cheese and American (full cream or whole milk) cheese.[1] Cottage cheese is soft and quickly perishable, therefore it is consumed while fresh. When made rather dry and packed in moisture-proof packages it may be shipped to points where delivery may be made within 24 to 36 hours. The first and second zones are usually the practical limits of shipping cottage cheese by parcel post.

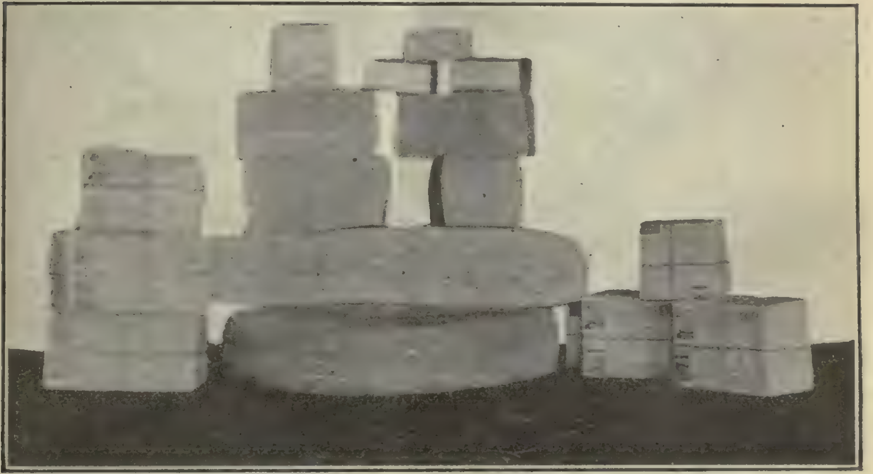

FIG. 4.—Cheese for parcel-post mailing. In some of the important cheese-producing sections Swiss and other varieties of cheese are frequently cut into suitable blocks for parcel-post shipping.

As American, Swiss, Brick, and several other of the firmer varieties of cheese are ripened or cured and paraffined before they are marketed, they can be more successfully shipped by parcel post than the soft varieties such as cottage cheese. The more common styles or forms in which the firmer varieties of cheese are marketed are prints, bricks, and cylindrical shapes. The prints are made by cutting the larger styles of cheeses into square "prints" weighing usually 1 pound each. Bricks are made in molds of the desired size. Cylindrical-shaped cheeses, both flat and long, are commonly known by various trade names such as Midgets, Picnics, Young Americas, Long Horns, Daisies, and Flats. On the Pacific coast a type of cheese called "Jack," which closely resembles the "Daisy" size, is marketed by parcel post. The usual weight and shape of several styles of cheese, suitable for parcel-post shipping, are shown in figure 5.

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[1] For information regarding the making of cheese Farmers' Bulletin No. 850, "How to Make Cottage Cheese on the Farm," may be obtained upon request of the Division of Publications of the U. S. Department of Agriculture.

THE PACKAGING OF CHEESE FOR PARCEL-POST SHIPPING.

General care should be exercised in the packaging of cheese for shipment by parcel post. The surface of the cheese should be clean and, if necessary, paraffined. As a protection to the cheese it should be wrapped in several layers of paper, preferably with a waxed paper next to the cheese. Corrugated or other fiber-board containers or wooden boxes may be used as shipping containers. (See figure 6.) When rather weak fiber board or wooden boxes are used they should be wrapped with several sheets of tough paper.

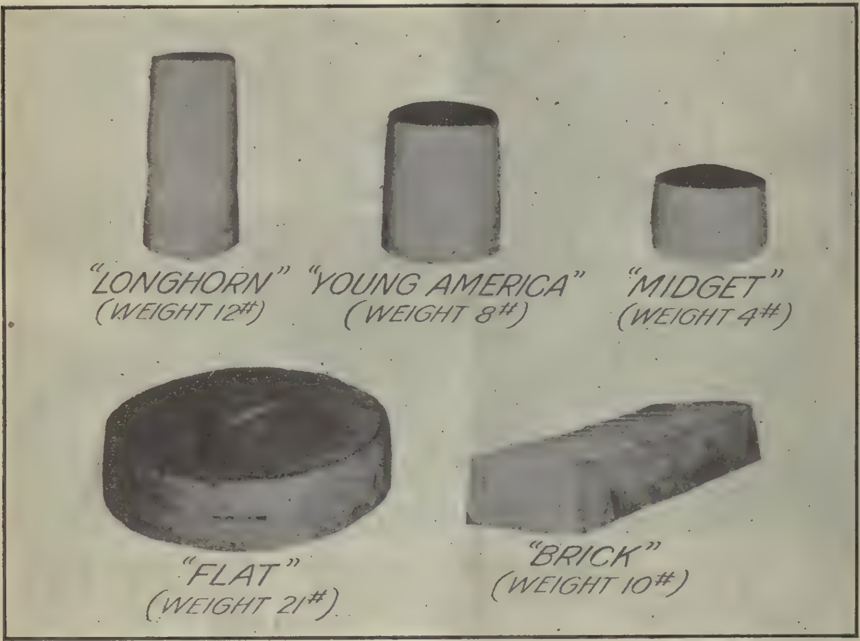

FIG. 5.—Various styles of American Cheddar cheese suitable for parcel-post shipping.

ADDRESSING AND MAILING PARCEL-POST PACKAGES.

Parcel-post packages, like other mail matter, should be carefully addressed, including the street number of the person to receive the parcel. In the upper left-hand corner the name and address of the sender should be plainly written (see illustration on front cover page). It is preferable to place all addresses on the package itself rather than on a tag tied to the package, for if the tag becomes detached the addresses of both the sender and receiver are lost. A rubber stamp for butter shipments bearing the statement: "Butter—keep away from heating apparatus," may be used to show that the parcel is perishable and should be handled accordingly by the postal employees. The letters in the word "Butter" should be one-half inch high, the others one-fourth inch high.

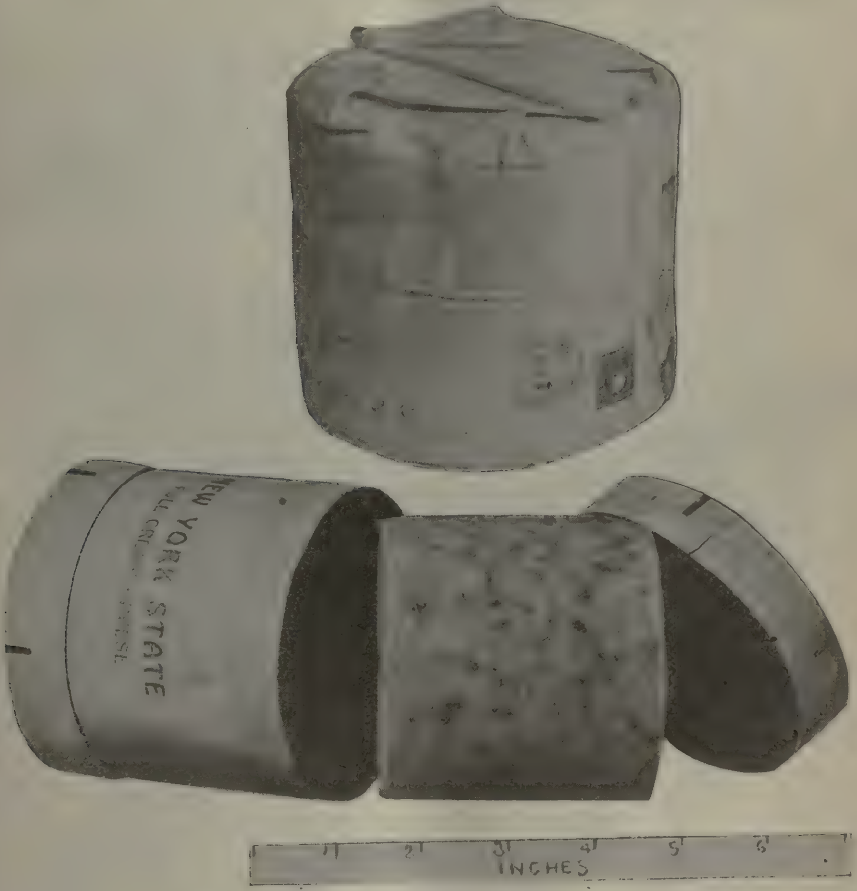

FIG. 6.—Suitable container for shipping cheese.

In shipping by parcel post such a perishable product as butter, which is affected by exposure to heat, inquiry should be made of the post office regarding the daily mail service for parcel matter from that point to the destination of the shipment. Arrangements should be made to post the packages as near as practicable to the mail time in order to obtain delivery in the quickest possible time.

Consideration should be given to the practicability of using night mail service when available, as the temperature is usually cooler at night than in the daytime. Night shipments to points within the first and second zones ordinarily are delivered early the next day.

In a general way the foregoing precautions suggested for butter should be observed in shipping cheese.

POSTAL REQUIREMENTS.

Postal regulations provide that—

> When it (butter) is so packed or wrapped as to prevent damage to other mail, it will be accepted for local delivery either at the office of mailing or on any rural-route starting therefrom.
>
> Butter will be accepted for mailing to all offices to which in the ordinary course of mail it can be sent without spoiling when suitably wrapped or inclosed or when packed in crates, boxes, or other suitable containers to prevent the escape of anything from the package, and so constructed as to properly protect the contents. More than 50 pounds can not be sent beyond the third zone.

The firmer varieties of cheese, not being liable to cause damage in the mails, need no special consideration when properly packaged. In some cases it will be found that the express can be used to better advantage than the parcel post.

The rates on parcel-post packages vary according to their weight and the distances shipped. Persons not familiar with the postal regulations governing parcel-post shipments may obtain specific information at any post office regarding the rates and limits of weight and measurement applicable to shipments to any other office.

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SOY BEANS IN SYSTEMS OF FARMING IN THE COTTON BELT

A. G. SMITH
Agriculturist

FARMERS' BULLETIN 931

UNITED STATES DEPARTMENT OF AGRICULTURE

OFFICE OF THE SECRETARY
Contribution from the Office of Farm Management
W. J. SPILLMAN, Chief

Washington, D. C. May, 1918

Show this bulletin to a neighbor. Additional copies may be obtained free from the Division of Publications, United States Department of Agriculture

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1918

THE SOY BEAN is destined to take a very important place in the agriculture of the cotton belt, not only as a means of improving the soil but also as a feed and commercial crop. It has already been grown with marked success in many parts of the South, and in one section of northeastern North Carolina has become a staple crop. This bulletin presents a brief description of the ways in which successful growers handle this crop in the Southern States.

SOY BEANS IN SYSTEMS OF FARMING IN THE COTTON BELT.

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COMMERCIAL PRODUCTION PROMISING.

IT IS THE PURPOSE of this bulletin to show how soy beans may be used in systems of farming in the cotton belt. The directions given are based on an economic study of soy beans in northeastern North Carolina, on widespread observations of soy beans growing under farm conditions in the South, and on miscellaneous data obtained from various other sources throughout the cotton belt. Except in northeastern North Carolina, where there is located the most important soy bean district in the country, and on a few scattered farms elsewhere, soy beans have not become a commercial product in the cotton belt; but economic conditions have changed, and in many areas of the South this crop may now be introduced with profit.

USES OF SOY BEANS.

The primary use of soy beans, as now handled in the South, is to improve the soil. It is a legume, and through the bacteria that form nodules on the roots of the plant it has power to use the free nitrogen in the air. Farmers say that ordinarily as a result of planting soy beans one year the yields of the succeeding crops are increased from 10 to 15 per cent, and where soy beans are planted in rotation for several years the yields of other crops are frequently increased by 50 per cent, apparently as a result of the soy bean alone. In northeastern North Carolina soy beans have practically replaced cowpeas, and the soy bean is now the only legume largely used for soil-improvement purposes in that section.

A second use of soy beans is as feed for live stock. Soy-bean hay is a valuable forage, excelling cowpea hay. Cattle and horses like it

NOTE.—Sincere thanks are expressed for aid received in preparing this bulletin to the farmers from whom most of the material was obtained; to Mr. C. E. Hope, who assisted in making an economic survey in the soy-bean area of North Carolina; to experiment-station workers, county agents, and specialists of the Office of Forage-Crop Investigations, with whom many of the conclusions were discussed; and to the cotton-oil companies, which have manifested a helpful interest.

better and it is more nutritious. The soy-bean hulls, stems, and leaves left from thrashing are used for feeding livestock, and some farmers feed nothing else to the work stock for roughage the year around. Waste beans left from harvesting, and soy beans planted in corn, are pastured by hogs with profit, and the forage left on the land is pastured by cattle and horses. A field of soy beans is sometimes hogged down without any other harvesting; but this is not a common practice, for the crop can generally be used more profitably in other ways. Soy beans make a soft pork, much like the peanut-fed product. The pork may be hardened by adding corn to the ration while pasturing or by feeding on corn alone after taking the hogs off of the soy beans.

Lastly, the bean itself is an important commercial product. The beans are sold for seed, for canning, and for using in other ways for human food, and for oil and meal. At present the demand for seed takes a large proportion of the beans produced. Canning companies use the beans for mixing with navy beans. Considerable quantities of beans are retailed to consumers, who use them much like navy beans. Of recent years cotton-oil mills have been using the beans for expressing oil and producing meal. The machinery that is used for crushing cotton seed can be used for crushing soy beans, and as the average cotton-oil mill is in operation only about half the year these mills can be used without added cost of equipment for handling soy beans. A ton of soy beans, 33⅓ bushels, will yield approximately 240 pounds of oil and 1,620 pounds of meal, the amount depending upon the character of the beans and the efficiency of the manufacturing operations. The remaining 140 pounds is invisible waste, mostly moisture driven off in the process of manufacturing. It costs practically the same to work soy beans in this way as it does to work cotton seed. If the mills were especially designed for crushing soy beans, it would probably cost less, for it is not necessary to delint and hull soy bean seed, as is done with cotton seed to extract the oil and produce the meal. The oil sells for about the same prices as cotton oil and is used in many similar ways. The meal sells for nearly a third more than cottonseed meal, for it contains a higher percentage of protein. It is valuable both for feed and for fertilizer, and ground soy bean cake made from clean saved beans has many possibilities as a food stuff, as it can be used in a variety of ways in cooking. The outlet for soy beans for crushing is therefore practically unlimited and the market for beans is assured.

Soy beans bring the highest prices for seed, somewhat less for canning and other food purposes, and least for crushing. For this reason, with the limited supply of American-grown beans that now go on the market, it is only after the other demands are supplied that the mills are able to buy. Nevertheless, cotton-oil mills are active in helping farmers to grow soy beans, with the idea that in the future the production will be so increased that large quantities will be left for crushing purposes. These mills are already using large imports of soy beans grown in Manchuria and would use the American beans if they could be obtained.

AREA AND SOILS ADAPTED TO SOY BEANS.

The area in the western part of the cotton belt that is well adapted to soy beans is limited to some extent by scant or irregular rainfall. In most of Texas, except in the eastern and northeastern parts, the rainfall is either insufficient or too uncertain for the crop to be profitable for seed year in and year out. In some years soy beans make a fair growth of forage, but only a small amount of seed. Oklahoma is like Texas, and the crop does well only in the more favored portions. (See fig. 1.) Outside of these two States the rainfall is suitable for growing soy beans throughout the cotton belt.

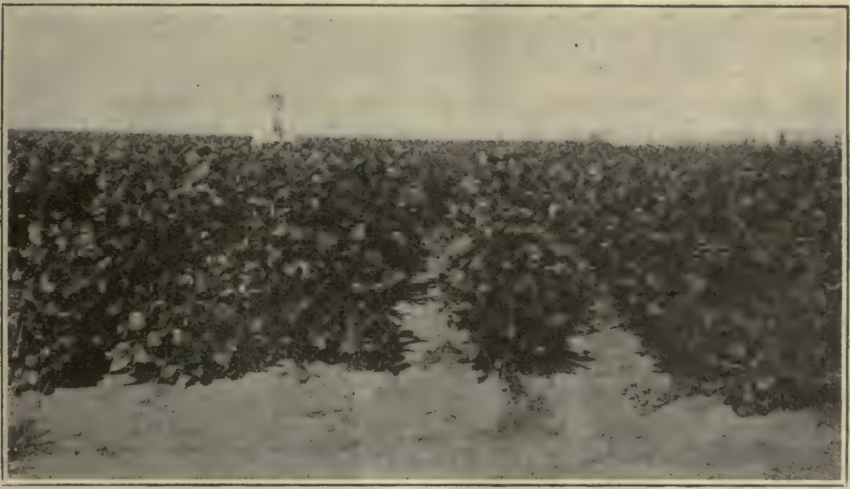

FIG. 1.—A field of soy beans in southeastern Oklahoma, grown for seed.

The soils best adapted to soy beans are the stiffer grades, although with good tillage, good crops may be grown on sandy loam types. In northeastern North Carolina the soil on which the best yields are made consists of a stiff top soil (which, however, contains some very fine sand) and a rather impervious subsoil. The land is drained by open ditches comparatively close together, and the water is frequently drained into the ditches by means of open furrows. There are other types of soil in this section, including some sandy loam, but farmers commonly say that the stiff soils are best for soy beans. On the sandy soils, even though the plant may grow as large, it usually does not fruit as well. The areas in the cotton belt that seem to be especially well adapted to soy beans are the black lands of Alabama and Mississippi and the Delta region of the Mississippi. Some farmers are already making a success of the crop in these areas. The piedmont section should grow beans successfully, and scattered plantings have proved profitable in this region. The stiffer soils in the coastal plain section of the South should also produce good crops of soy beans. In fact, outside of the sandy soils or some of the sandy-loam soils containing a high percentage of sand, most of the cotton belt that has sufficient rainfall is well adapted to soy beans.

BEARING ON OTHER LEGUME CROPS.

Other legumes that are extensively grown in the cotton belt are peanuts, cowpeas, and velvet beans. The peanut is not a serious competitor of soy beans, since peanuts grow best on the sandy and sandy-loam types of soil. In North Carolina where there is a peanut district adjoining the soy-bean district, the peanuts are produced almost exclusively on sandy-loam soils and the soy beans on stiffer soils. Although the two districts are much alike except in the matter of soils, the two crops are practically noncompetitive because of the soil requirements of each crop. On some farms both soy beans and peanuts are grown, but farmers make a practice of planting the soy beans on the stiffest lands and the peanuts on those that contain the most sand.

Cowpeas, like peanuts, thrive best on sandy or sandy-loam types of soil, and therefore there should be little competition between soy beans and cowpeas on the stiff soils where soy beans do best. Soy beans replaced cowpeas in northeastern North Carolina for three reasons; the better adaptability of the soil for growing soy beans, the frequent failure of cowpeas to produce seed; and the greater ease with which soy beans can be harvested. Soy beans are a more certain seed crop than cowpeas, so no difficulty has been experienced in obtaining planting seed in the soy-bean district, and, as will be explained later, soy-bean seed are harvested with mechanical pickers, while cowpeas must be picked by hand and thrashed or cut and thrashed. For these reasons, except on the more sandy phases of soil, soy beans, when handled intelligently, are usually a better crop than cowpeas.

Velvet beans do well on both sandy and stiff soils. Their special use is for planting in corn, and for this purpose they compete with soy beans. They do not, however, always mature seed in the northern limits of the cotton belt, while soy beans can be grown in much colder climates than can cotton. Where no other crop is planted, soy beans are preferable on stiff soils, for the yields of seed are as high or higher than velvet beans, and the crop is more easily harvested. On sandy soils, however, the velvet beans should make the better yield.

As a money crop, the soy bean has an advantage in a wider market, which makes the crop easier to sell. Furthermore, soy beans at present command a much higher price than do velvet beans. There is a large place for both crops in southern agriculture, and on many farms both should be included in the same system.

COMBINING SOY BEANS WITH OTHER CROPS.

Soy beans have a long planting period, beginning with corn planting and lasting in the South until the early part of July. Regardless of the time they are planted within this period, there is rarely more than a week or ten days difference in the date of maturity. This permits the crops to be used in various combinations, which may be determined by soil, climatic, and economic conditions. Briefly stated, the different ways in which soy beans are planted in the soybean district of northeastern North Carolina, or in other parts of the South, are as follows:

1. As a first crop for seed, occupying the land for a whole season, with the beans planted in rows usually after the cotton is planted.
2. As a first crop for hay, sown broadcast, at about the same date as the first crop for seed is planted.
3. In the row with corn.
4. In alternate rows with corn.
5. As a second crop for seed planted after small grain or Irish potatoes.
6. As a second crop for hay, planted after small grain or Irish potatoes.
7. Sown broadcast or drilled in corn at the last working.
8. Drilled in alternate rows of cotton at the last working.

Throughout the cotton belt wherever soy beans can be successfully grown, one or more of these ways can be used.

AS FIRST CROP FOR SEED.

The most common method of planting soy beans is as a first crop for seed. In this way, on medium or stiff soils which may be difficult to prepare for a second crop after small grain, soy beans can be grown to good advantage in cropping systems that include cotton, corn, and velvet beans. By planting from one-fifth to one-third of the crop land in soy beans and with either soy beans or velvet beans planted in the corn, a profitable combination of crops can be developed. In this combination, which, except for the use of velvet beans in corn, is practiced quite extensively in Hyde County, N. C., the stems, leaves, and hulls left from the soy beans when cut and thrashed furnish rough feed for the live stock. Where a picker is used, most of the roughage is left on the land. Furthermore, where the land is fertilized, as it is over a large portion of the cotton belt, the soil fertility can be maintained or increased by this system. The labor required in growing a first crop of soy beans does not conflict seriously with work on other crops, except perhaps during the period of cultivation. The planting is done after the cotton is planted, so there is not much conflict at that time. The soy beans can be cultivated with a two-horse cultivator, which can be used on cotton and corn, at least during a part of the season.

Growing soy beans in connection with cotton and corn in this way tends to promote the use of two-horse implements, for, as the labor required for harvesting soy beans is less than for cotton, a large acreage of crops can be grown per man. Where soy beans are grown extensively it is not uncommon for farmers to use two-horse implements and grow as much as 40 acres of crops per man, the acreage being divided about equally between cotton, corn, and soy beans. The time for harvesting mammoth yellow soy beans in northeastern North Carolina is the last of October or the early part of November, and while this time conflicts with that of harvesting cotton and corn, soy-bean harvesting requires such little labor, and the other crops, particularly corn, can so often be left a little time without deteriorating, that farmers usually do not encounter serious difficulty in getting the work done. Even if only a small part of the crop land is planted in soy beans for seed as a first crop, the man-labor and horse or mule labor is better utilized than when soy beans are omitted, and the farm is usually made more profitable, especially when the soil improvement is considered.

AS FIRST CROP FOR HAY.

Soy beans are often planted for hay as a first crop where it is felt that the land is too poor to make it profitable to cultivate the beans for a seed crop. In this way they are used very much as cowpeas are often used on poor land, planted primarily for the soil improvement, but, if the growth happens to be large enough, also to be cut for hay. The work in this case fits in very well with that on other crops. The beans are sown broadcast, or drilled in after the cotton is planted, and there is nothing more to do until the hay is harvested. With mammoth yellow beans, this is usually about the last of August, when there is ordinarily little or no work to be done on cotton or corn. In some sections this work may conflict with fodder pulling, but it is noticeable that in the soy-bean district only a small part of the fodder is pulled; on most farms it is all left on stalks. On a few farms the soy beans are sown early for hay, cut in July, and followed by a crop of late potatoes.

IN THE ROW WITH CORN.

Soy beans can be used to good advantage for planting in the row with corn. Some farmers plant between the hills of corn at the time the corn is planted, but many object to this method on the ground that the beans start up more quickly than corn and check the growth of corn, thereby decreasing the yield of the latter. If, however, the beans are planted in the row when the corn is about six inches high, the yield of corn is not affected; and any growth of beans, except for the cost of planting, is clear gain.

Drilling soy beans in the row when the corn is planted is not extensively practiced, but where corn is grown for ensilage, and both the corn and beans are put in the silo, there is an increase in the total yield of ensilage, even though there may be a small decrease in the yield of corn. It would seem that this method of planting soy beans should have a wider use.

Soy beans planted in the rows of corn can be used for pasturing with hogs or cattle after the corn is husked out. Some farmers, however, harvest the beans for seed, either by pulling the beans or cutting them with a sickle, after which they are thrashed or flailed out; or the stalks of corn are cut out and the beans harvested with a picker.

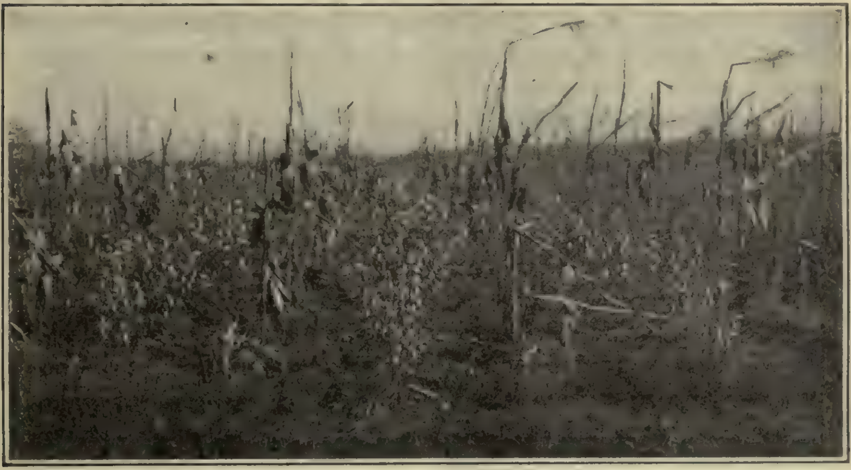

FIG. 2.—Soy beans planted in alternate rows with corn. The beans are ready to harvest.

WITH CORN IN ALTERNATE ROWS.

The method of planting corn and soy beans in alternate rows (see fig. 2) is followed on several farms with good results. The practice is increasing, particularly in areas with sandy loam soils where soy beans have been grown for only a few years. Farmers around Hertford, N. C., who are planting soy beans and corn in this way get considerably more than a half crop of corn and a half crop of soy beans, some even as much as three-fourths of a crop of each. The corn is planted thicker in the row than ordinarily, as it has more air space and sunlight than when planted as usual, and also more root space, since the roots of the soy beans do not spread as far as the corn roots. The corn is planted early, and the beans are planted when the corn is from 1 to 2 feet high. Both are cultivated just alike—usually with a two-horse cultivator. The rows are generally from 3 to 3½ feet wide, but sometimes they are placed closer together, in which case the cultivating is done with one-horse implements. On some farms the beans are grown successfully between corn rows when the corn rows are only 5 feet apart. Some farmers who have a medium soil and who grow cotton, corn, soy beans, and peanuts, plant about one-third cotton, one-third corn, with soy beans in alternate rows, and one-third peanuts. In harvesting, the beans are picked with a picker and the corn husked later. This system is open to the objection that if the corn should blow down there may be some difficulty in harvesting the beans.

SOY BEANS AFTER SMALL GRAIN OR IRISH POTATOES.

In Hyde County, N. C., on a loamy soil of medium texture, soy beans are found to be very profitable when planted after small grain as a second crop. The beans are planted either for hay or seed, but they are usually most profitable when grown for seed. It is often hard to get the grain crop harvested and the soy beans planted in the short time available, and at the same time to cultivate the cotton crop, but it is no more difficult than harvesting grain and planting cowpeas, which is done on many of the better farms throughout the South. The time for harvesting for seed and for hay is usually a week or 10 days later than the harvesting period of the first crop.

Soy beans are an excellent crop to plant after early Irish potatoes. The potatoes come off some time before the time for harvesting small grain, and the land is usually left in such condition that it can easily be prepared for soy beans.

A good yield from soy beans as a second crop can not be expected if the fertility of the land is low. If the land is poor the beans should be planted as a first crop.

The texture of the soil and the amount of rainfall largely determine the feasibility of growing soy beans as a second crop. Soils that bake and become hard in dry weather often can not be prepared for a second crop in the middle of the summer. Soy beans, for a second crop, are therefore an uncertain proposition for such soils. The same trouble is experienced with cowpeas in several parts of the South, particularly the Piedmont. On medium soils, such as the Portsmouth sandy loam and the Orangeburg sandy loam, this difficulty is not often experienced, and soy beans should do well on these soils when planted after small grain or early Irish potatoes.

If the second crop is to do well there must be a sufficient supply of rain during July and August. Sections that have a limited rainfall during these months can not grow a good yield of soy beans as a second crop, and they are not the best areas even for them as a first crop.

IN CORN AT LAST WORKING.

One of the more profitable ways of planting soy beans is in corn at the last working The seed may be either sown broadcast or drilled. The plants grow from 12 to 24 inches high, and if harvested these often yield from 4 to 10 bushels of seed per acre. Farmers in the soy bean district stated that this growth of soy beans in corn was worth from $5 to $10 per acre for pasture for hogs and cattle after the corn was husked, to say nothing of the soil improvement. Sometimes a farmer will cut the beans with a sickle and thrash them out for seed.

IN ALTERNATE MIDDLES IN COTTON.

Rows of soy beans can be planted in alternate middles in cotton, as cowpeas are often planted in the South Atlantic States. Every other middle is left vacant to give the cotton pickers a place to work. The beans can either be turned under for soil improvement, grazed, or harvested like soy beans planted in corn at the last working.

VARIETIES OF SOY BEANS AND SEED REQUIRED PER ACRE.

Taking the cotton belt as a whole, the mammoth yellow [1] is the best variety of soy bean to plant. No other variety even approaches it in acreage planted, and, for all conditions, no other has proved a better yielder. The experiment stations are testing numerous varieties, and a better variety eventually may be found; but for the present farmers in the cotton belt can do no better than to plant the mammoth yellow, although for special conditions, such as early beans for hogs, other varieties may be more satisfactory. The mammoth yellow is suitable for both seed and hay, and is well known in commercial channels. It is a yellow bean and a variety that is suitable for human food. Cotton-oil mills like it on account of its oil content and its color, for it makes a yellow meal which is acceptable to farmers who are accustomed to cottonseed meal, and who look upon a dark-colored meal as one that is damaged. The mammoth yellow soy bean grows erect and stands up well, so that it can be harvested with a mechanical picker, which is not the case with several other varieties. At least 90 per cent of the soy beans grown in the cotton belt are of the mammoth yellow variety.

In northeastern North Carolina there is a brown soy bean that is preferred for forage, and frequently yields more seed than the mammoth yellow, but as it sells for a much lower price on the market it it is not grown except for home use.

Old soy bean seed should not be planted, since but very little of it will germinate. In the soy bean section of North Carolina an average of three-fourths of a bushel of seed is used per acre when planted for seed and two bushels per acre when planted for hay. To keep the plants from growing too large and from branching too much, heavier seedings are made on the best lands. It is generally considered that the plants should be from two to three inches apart in the row. In planting in the corn row, from one-fifth to one-half bushel per acre is sufficient. In planting in corn at the last working an average of one bushel per acre is used.

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[1] Outside of the cotton belt other varieties of soy beans do as well or better than the mammoth yellow. Generally speaking, the mammoth yellow should not be grown for seed more than 100 miles north of the cotton belt. North of the Ohio River it does not always mature seed.

FARM PRACTICE IN GROWING SOY BEANS.

INOCULATION.

In most of the cotton belt nodule-forming bacteria for soy beans, which make the free nitrogen of the air available, are already in the soil, but usually in limited quantities, and for the sake of safety inoculation frequently is advisable. This inoculation can be made in several ways. One is by transferring soil to the new field from a field where soy beans have been successfully grown and nodules have formed on the roots of the plants. Care should be taken to keep the inoculating soil out of the sunlight from the time it is taken out of the old field until it is worked into the new. A cloudy day or a time early in the morning or late in the evening should be chosen for making the transfer. Two hundred pounds or more of soil should be used per acre and should be harrowed into the soil immediately after scattering. Another method is to inoculate the seed with artificial cultures. In some States these cultures can be obtained from State agencies at a nominal cost. Directions for using the cultures accompany each package. Still another way is to moisten the seed with a thin solution of molasses and water and then thoroughly mix fine dry dirt from an old soy bean field with the seed. After the seed is dry it can be planted in the usual way.

Nitrogen-bearing fertilizers have the same effect on the growth of the soy bean as do the nodule-forming bacteria, and often when planting them for the first time farmers fertilize with 200 pounds of cotton-seed meal per acre to insure a crop while the nodule-forming bacteria are developing in the soil.

Some nodule-forming bacteria are usually carried with seed that is not artificially inoculated, owing to the fact that in the process of harvesting and thrashing the seed become more or less coated with soil dust, and farmers say that where soy beans are planted without either inoculating or fertilizing with cottonseed meal, the yields increase from year to year, until three crops of beans have been grown on the land. This is evidently due both to the improvement in the inoculation and to the increase in fertility of the soil, but largely to the inoculation. The bacteria carried with the seed or the limited number already in the soil multiply from year to year until the supply is sufficient.

DISTANCE BETWEEN ROWS.

The distance between rows in planting soy beans is about the same as for cotton, commonly from 3½ to 4 feet. Closer planting, however, gives better yields, and some farmers make the rows 2 feet apart. The implements used in cultivating determine to some extent the distance between rows. Where the cultivating is done with one-horse implements ordinarily the distance should not be more than 30 inches, but where an ordinary two-horse corn cultivator is used the rows should be 3 feet or more apart. This, however, may cause a sacrifice in yields for the sake of ease in cultivating. The rows must be 3 feet or more apart if a picker as now made is to be used in harvesting. Most soy beans grown for seed are planted in rows 3 feet or more apart.

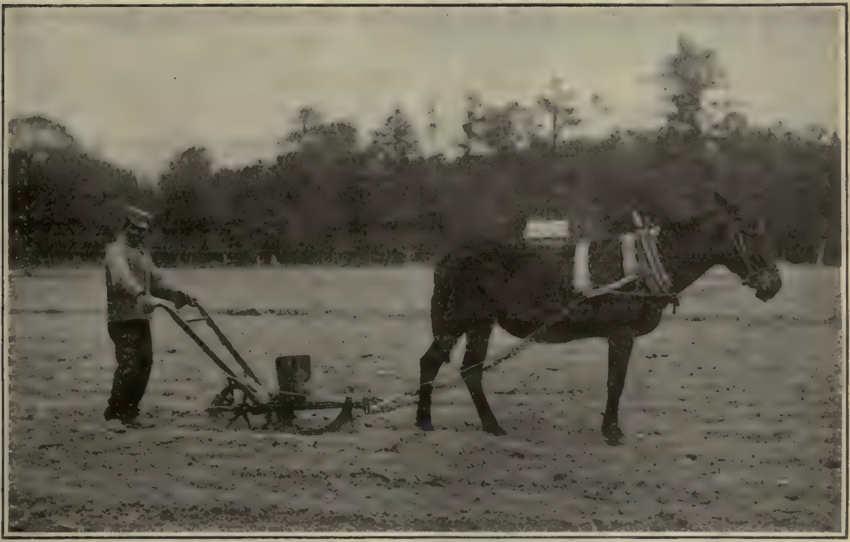

FIG. 3.—Planting soy beans with a cotton planter.

PLANTING AND CULTIVATING.

Where soy beans are grown for seed as a first crop—that is, where they occupy the land for a whole season—they are planted very much like cotton. They are rarely planted below the level of the land. but rather on the level or on a slight ridge. Except as regards fertilizing, there is no serious mistake in planting soy beans like cotton, and this method is commonly followed when the soy beans are grown as a first crop. They are planted with either a corn planter or a cotton planter (see fig. 3) with plates. The soy beans on most farms where they are grown for seed in the soy-bean district (see illustration on title page) are commonly cultivated with two-horse cultivators. They are cultivated from two to four times. There is but little hoe work. The plants start off quickly, and it is possible to plow close to them and throw the earth into the row and kill weeds before thay get a good start. Many farmers never use a hoe in cultivating soy beans. In planting after oats or wheat the rows are usually closer together, commonly 2 feet apart, so a different method is used. In this case the beans are planted practically on the level and cultivated with one-horse implements.

Another method of planting, but not practiced in the cotton belt, although in some places it could be used, is to plant the beans on well-prepared land with a grain drill (see fig. 4) closing up some of the feed holes so the rows will be from 24 to 30 inches apart. Four rows are planted at a time in this way, and the cultivating is done with a four-row sugar-beet cultivator. This method is particularly advisable where the land is level and not too weedy.

Soy beans for hay are planted just like cowpeas. The best method is to prepare the land and then plant the beans with a grain drill. Another method is to sow the beans broadcast by hand and then plow them under, but this is not always satisfactory, since many of the beans are covered too deep and do not come up. A better method than this is to break the land, sow the soy beans broadcast, and then harrow them in with a disk harrow or a smoothing harrow.

Where soy beans are planted in corn at the last working, the beans are sown broadcast by hand and are covered as the corn is cultivated.

In planting soy beans in the corn row between hills the beans may be planted when the corn is planted or, better, when the corn is about 6 inches high. When planted at the same time, the corn and beans are both planted with the same planter, there being two hoppers,

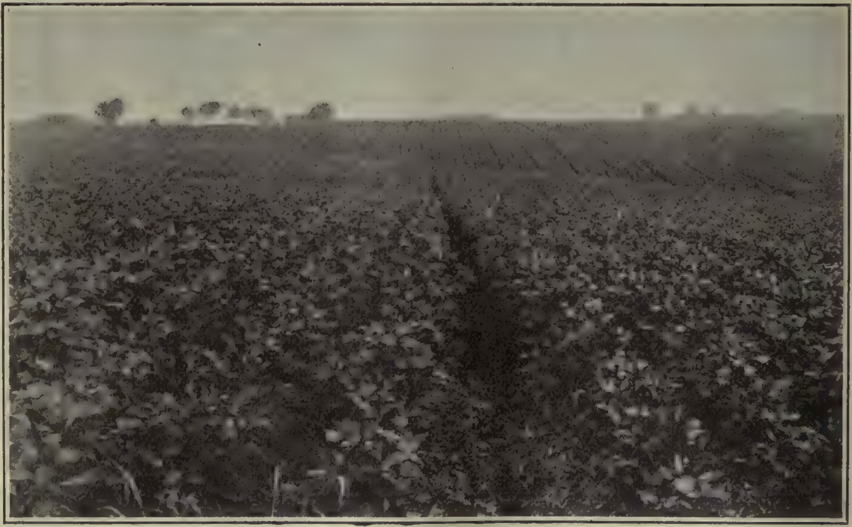

FIG. 4.—Field of soy beans at Danville, Ky., planted with a grain drill and cultivated with a sugar-beet cultivator, 4 rows at a time. This method might be used to advantage in the cotton belt.

one containing corn and the other soy beans, the corn and beans being dropped alternately. When planted after the corn is up, the beans are planted with a hand planter or with a hoe. Where the beans are drilled in the row with corn, the beans and corn may be mixed together and planted with one hopper, or two hoppers may be used and the beans and corn drilled from separate hoppers. In any case the soy beans should be planted not over 2 inches deep.

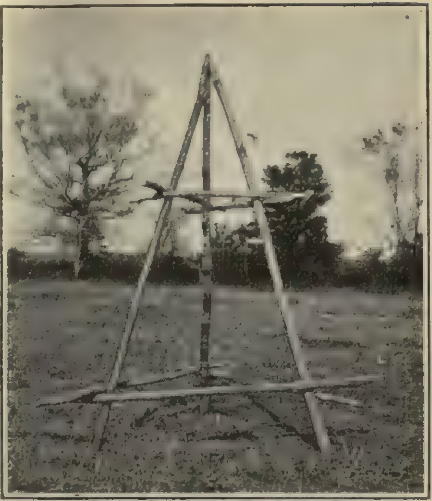
FIG. 5.—Hollow rack used for curing soy bean hay.

FERTILIZERS USED.

Like cowpeas, soy beans are not heavily fertilized, if at all, farmers usually depending upon the residual effect of the fertilizers applied to other crops. Lime, applied as ground limestone, ground oyster shell, or burned lime usually increases the growth of soy beans (except in limestone areas), but it is not always needed to produce a profitable crop. In actual practice most of the farmers in the soy-bean district of North Carolina use some form of lime, since most of the soil there is acid. The lime is secured quite easily, and the increased yields considerably more than pay the cost. The lime is applied at the rate of 2 tons of ground limestone per acre once in four or five years, or it is scattered on top of the row at the rate of about 1,000 pounds per acre just before the soy beans are planted. Light applications, occasionally as low as 150 pounds per acre, are frequently drilled in a furrow and covered, the beans being planted above.

Sometimes acid phosphate is used. This is applied generally at the rate of 200 pounds per acre and is drilled in the row before the beans are planted. On soils deficient in potash kainit is sometimes used, but the most common practice with both acid phosphate and kainit is to fertilize the preceding crops and depend upon the residues for the soy beans. Cotton-seed meal, as previously stated, is sometimes used when planting soy beans for the first time, and sometimes on other plantings where the soil is sandy or sandy loam. The common application is from 100 to 200 pounds per acre, drilled in the row before planting the beans.

HARVESTING.

The difficulty farmers have experienced in harvesting has been the greatest handicap in the extension of the production of soy beans.

The development of new machines and accumulated experience with the crop, however, have overcome most of the troubles, so that farmers in the soy-bean district consider it little, if any more, trouble to harvest soy beans, except for hay, than it is to harvest oats or wheat.

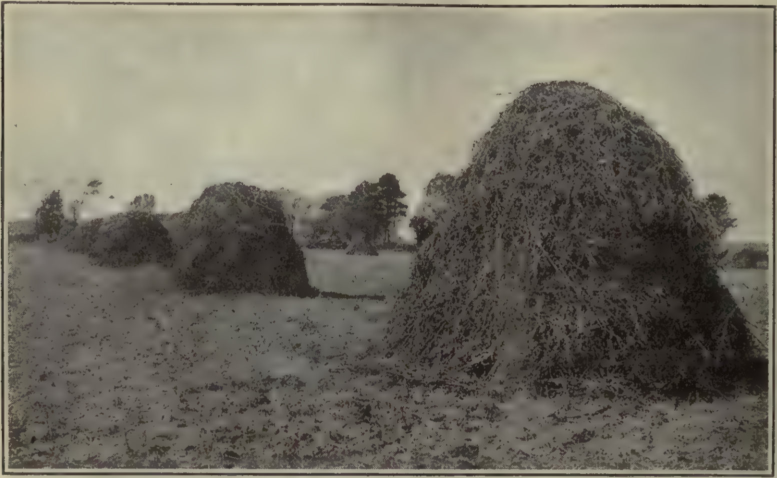

FIG. 6.—Soy bean hay stacked on hollow racks.

Harvesting soy beans for hay is practically the same process as harvesting cowpeas for hay. Any difference is in favor of the soy beans, for the vines grow more erect and do not become tangled like cowpeas. Soy-bean hay is usually made by cutting when the pods are half filled and partially curing in the swath before raking. Sometimes a tedder is used for curing, but not often. After the soy beans are raked into a windrow they may be hauled directly to the stack or barn, but the usual custom is to shock them on hollow racks made of poles as shown in figure 5. When the soy beans are shocked on these racks (see fig. 6), there is a hollow space on the inside which allows a passage of the air and causes more rapid and thorough curing. The hay is so thoroughly cured on these racks that it can be baled out of the shock (see fig. 7), which frequently is done. The usual custom, however, is to store the hay loose in the barns.

In harvesting soy beans for seed mechanical pickers (see fig. 8) are used quite extensively. These pickers are of different makes, but all have the same general principle. They run astride the rows and knock out the beans, leaving the stems, leaves, and hulls on the land. The machine is drawn by two mules and operated by two men. One man drives and another throws out the excess trash that accumulates in the back of the machine. The picker will hold from 4 to 6 bushels of beans. When it is full, the beans are emptied and handled in different ways. In one common method the beans are run through a half-inch mesh sieve to remove the coarse trash and then are sacked. One or two men handle the sieve. These men may be the same who operated the machine or they may be extra men. After this the beans are cleaned with a fanning mill.

Harvesting with a picker begins some time after the leaves of the plant have fallen (see fig. 9). The time to begin is when the first pods pop open and throw out the beans. As the picker works best only when the beans are dry, the machine is not started in the morning until the dew is off, which is usually from 9 to 11 o'clock. When the day's work is once started, it is customary to continue work until nightfall without stopping for dinner. In the soy-bean district picking usually begins about the last of October and lasts through approximately 10 days of good picking weather. If it rains, the maturing of the beans is checked and picking is resumed when the weather again becomes dry. A machine will pick from 3 to 6 acres per day, averaging about 4½ acres. In a season a machine will pick from 30 to 50 acres, but it is rarely safe to attempt to harvest more than 40 acres with one machine, since if left until the end of the season too many of the beans pop out before they can be harvested.

The waste of beans in picking usually varies from one-twentieth to one-fourth, and, as a rule, averages about one-eighth. If the plants are blown down or have long branches so the machine can not handle them well, the waste may be more than this, or if the beans are left on the vines too late, so that many of them pop out, the wastage may be higher. Varieties of beans that begin fruiting some distance from the ground can be harvested with the least waste by a picker, and this is

FIG. 7.—Baling soy bean hay in the field from hollow racks.

one advantage of the mammoth yellow soy bean. Hogs are usually turned in to clean up the waste beans, so that in fact there is very little loss.

A picker costs about $125, and so is within the reach of many farmers. A farmer with a small acreage of soy beans frequently buys a picker and, in addition to his own work, does custom work for his neighbors. In this way his machine is profitably used. The common price for picking beans with a picker is 20 cents per bushel, or a toll of one-tenth of the beans. In northeastern North Carolina approximately four-fifths of the beans grown for seed are harvested with pickers. Altogether there are now in use over 1,500 pickers, some of which have been in use for 10 years and have picked over 8,000 bushels of beans. It is noteworthy that the pickers are replacing other methods of harvesting and that the increase in the acreage of soy beans in the cotton belt can be attributed largely to these machines.

Another way of harvesting the soy beans is to cut them with a binder and thrash them out with a grain thrasher (see fig. 10) adjusted for handling beans. This method has an advantage in some cases, in that the stems, leaves, and hulls may be saved for forage if so desired, whereas with the picker most of these are returned to the soil, although a part of them may be eaten by cattle and horses turned in after harvesting. This, however, is frequently an advantage on the side of the picker, for the farmers often prefer to have

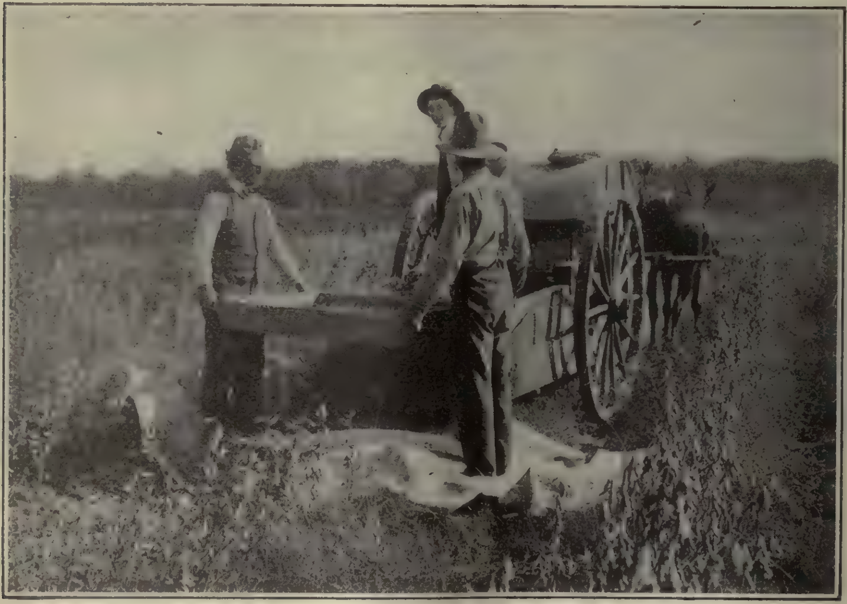

FIG. 8.—Emptying a soy-bean picker and screening the beans.

their material returned to the land for soil improvement. The soy beans, when harvested with a binder, are cut earlier than when harvested with a picker, since to save the seed they must be cut before the pods start bursting open. After the beans are cut they are shocked like oats or wheat and left standing until thrashed. Soy beans after shocking are not damaged seriously by bad weather, and are often allowed to stand in the field for a month. There is some waste in harvesting when the beans are cut with a binder, but it rarely exceeds one-twentieth of the crop. The price paid for thrashing beans is usually a toll of one-eighth. In thrashing soy beans the grain thrasher is adjusted so that the cylinder runs more slowly than when thrashing grain, while the rest of the machine runs at the usual speed. This is arranged by using larger pulleys on both ends of the cylinder shaft. Also a part of the cylinder and concave teeth are removed. With these changes not many beans are cracked.

The old-fashioned self-rake reaper is also used in harvesting soy beans, leaving the bean vines on the ground in loose bundles. Three rows of these bundles (see fig. 11) are sometimes thrown into one by a man with a fork. Whether the beans are piled in this way or left to lie as they are dropped from the reaper, they are allowed to cure for three or four days before thrashing. The reaper is used in a section where oats are little grown and where ordinarily a binder is not needed. In point of cost of the machine the reaper is more economical than a binder, since it costs only about half as much. The quality of the beans harvested with a picker is usually regarded as higher than that of beans harvested with a binder or reaper and thrashed.

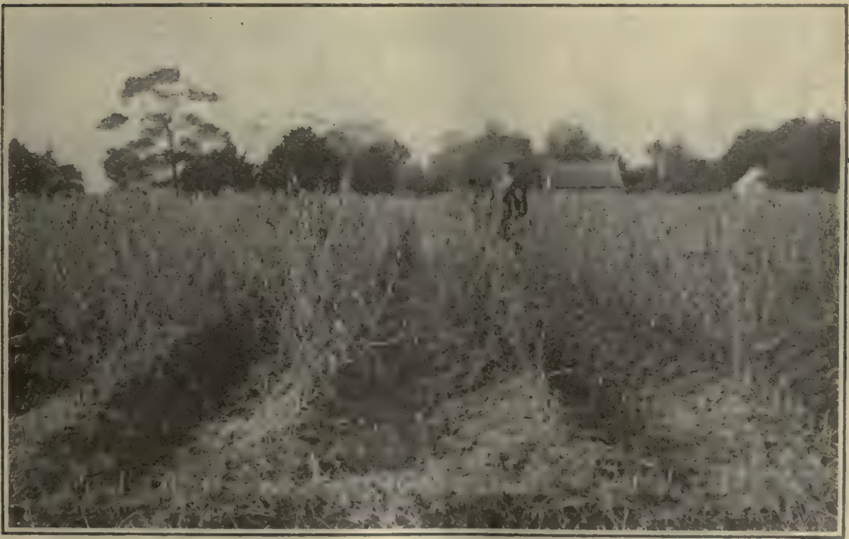

FIG. 9.—Field of mammoth yellow soy beans ready to harvest for seed.

There is less damage from bad weather, and the beans are not cracked. A dealer in purchasing beans without seeing the sample would prefer beans harvested with a picker.

YIELDS.

The yield of soy beans is dependent upon soil and seasonal and cultural conditions; hence, as may be expected, there is considerable variation. On 50 farms studied in northeastern North Carolina the lowest yield in 1916 was 4 bushels and the highest 39, averaging 18.9 bushels exclusive of the waste beans. Occasionally a farmer harvests over 40 bushels per acre, but this is not usual. Perhaps the yield that may be expected can best be indicated by comparing the yield of soy beans with that of corn. On the farms studied the yield of corn averaged 29.7 bushels, or the yield of beans was a little over 60 per cent of the yield of corn. As a general proposition it may be stated that in the cotton belt on soils adapted to soy beans the yield in bushels will approximate three-fifths that of corn.[1]

In addition to the beans there are the stems, leaves, and hulls left from thrashing or picking. The weight of these when dried will vary with the fruiting of the plants and the variety of the beans, but on an average, where the beans are thrashed, it will, in the case of the mammoth yellow beans, just about equal the weight of the beans.

Soy beans are planted thicker for hay than for seed, so in this case the weight of the forage per acre is heavier than when the beans are planted for seed. The hay commonly yields from one to two tons per acre. Land that will produce 30 bushels of corn in the cotton belt should yield around two tons of soy-bean hay per acre.

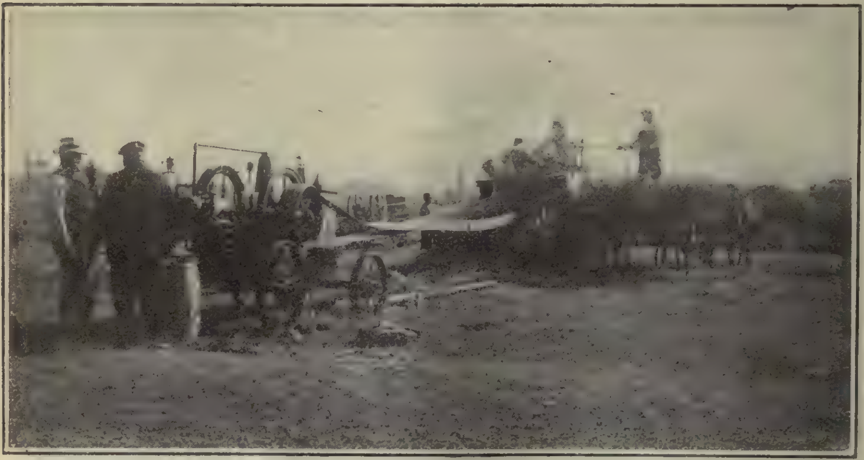

FIG. 10.—Thrashing soy beans.

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[1] A bushel of soy beans weighs 60 pounds and a bushel of shelled corn 56 pounds.

COMPARATIVE LABOR REQUIREMENTS.

The amount of labor required in growing soy beans for seed is on the whole about the same as that required for growing corn. Compared with cotton the labor requirement of a crop of soy beans is much less. With crops of 1,200 pounds of seed cotton and 20 bushels of soy beans per acre, the man labor in growing soy beans is one-third and the mule labor, including harvesting, three-fourths that of cotton. On an average farmers do about one-eighth as much hoe-work for soy beans as for cotton, but most farmers do not hoe the beans at all.

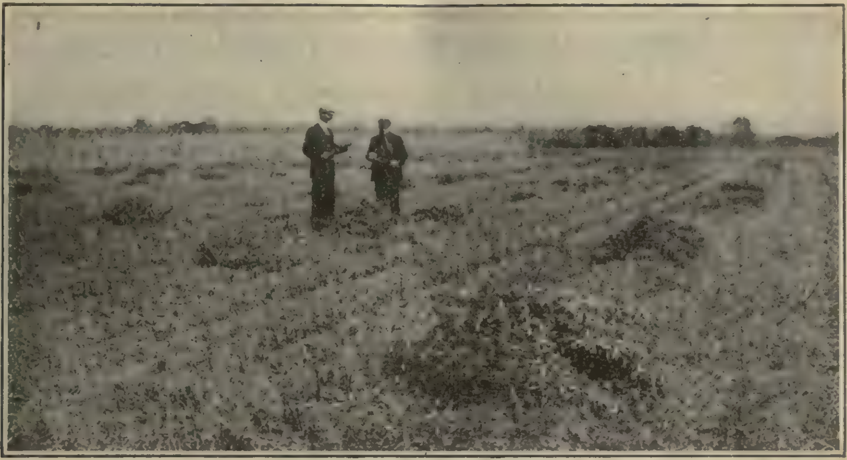

FIG. 11.—Soy beans cut with a self-rake reaper and piled in small bunches for curing preparatory to thrashing.

As a general proposition the cost of producing an acre of soy beans for seed is the same as the cost of an acre of corn. The costs will run so close together that one can safely figure on this basis. The cost of producing an acre of soy beans for hay is practically the same as the cost of an acre of cowpea hay. It costs approximately twice as much to grow an acre of cotton as it does to grow an acre of soy beans.

SELLING PRICES OF SOY BEANS AND SOY-BEAN FORAGE.

The price of soy beans within the last few years has been subject to wide fluctuations. In some years, before soy beans were used for food purposes, and before the oil mills bought them, they sold as low as 60 cents per bushel. In normal times the selling price has been around $1 per bushel. In 1916, however, most of the crop in the soy-bean district was marketed for about $2 per bushel, and in the spring of 1917 considerable quantities of beans were sold for seed purposes at $5 per bushel. In the fall of 1917 beans were commonly quoted at $2.50 per bushel in the local market. In selling beans it is usual for the purchaser to furnish the sacks. This practice probably will develop throughout the cotton belt.

Soy-bean hay sells for about the same price per ton as alfalfa hay. The stems, leaves, and hulls left from thrashing sell locally for about three-fifths as much, but there is no other market for them.

DIVISION OF CROP WITH CROPPERS AND TENANTS.

Landowners who rent land to croppers or tenants usually charge the same rent for land planted in soy beans as for land planted in corn. This is usually one-half of the crop for croppers and one-third for tenants.[1] If the beans are thrashed, each party pays for his share of the thrashing, and the party owning the work stock gets the stems, leaves, and hulls left after thrashing. If a picker is used, the landowner usually furnishes it and charges the cropper or tenant for picking his part of the beans. Now and then the picker is owned in partnership. Sometimes the landowner furnishes rent free land low in fertility in order to get the soil improvement.

If the land is rented for cash, the same charge is made when it is planted in soy beans as when planted in corn.

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[1] Croppers furnish only their labor and a share of the fertilizer, while tenants furnish labor, teams, implements, and a share of the fertilizer. Both classes furnish fertilizer in proportion to the share of the crop they receive.

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RODENT PESTS OF THE FARM

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Assistant Biologist

Columbia Ground Squirrel

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FARMERS' BULLETIN 932

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Biological Survey

E. W. NELSON, Chief

Washington, D. C. Issued July, 1918

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THE ANNUAL losses from rodent pests in the United States have been estimated as fully $300,000,000.

About two-thirds of the damage is inflicted by house rats and mice (both introduced from the Old World) and the remainder by native species.

This enormous waste of resources may be greatly reduced and largely prevented through systematic and organized campaigns against the noxious species.

The bounty system effects no permanent relief from rodents and is far more costly than the use of poisons.

The Bureau of Biological Survey has developed and perfected practical methods of extermination which have been successfully applied over wide territory.

The Bureau cooperates with the public in organizing and carrying out systematic campaigns against animal pests and invites correspondence on the subject.

Protection of their natural enemies is urged as an important aid in controlling rodent pests.

RODENT PESTS OF THE FARM.

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INTRODUCTORY.

RODENTS are among the most persistent and aggressive of the animal enemies of the tiller of the soil, and against them he is often more helpless even than against insect pests, because he has had less instruction as to their habits and the means of fighting them. To assist him by giving short accounts of the more important rodents that injure farm, ranch, and orchard, together with brief practical directions for destroying the pests, is the purpose of this bulletin.

The rodents of North and Middle America include about 77 distinct groups called genera, 44 of which have representatives north of Mexico. These 44 groups include about 750 forms that inhabit the United States and Canada. Many of them live in deserts, mountains, and swamps and rarely come in contact with cultivated crops. These, therefore, can not be classed as injurious; and, indeed, many of them are beneficial to the soil, as they stir it up and fit it for future agricultural uses. A few rodents feed largely upon insects and help to keep a check upon the hordes of grasshoppers and similar pests. Certain of the rodents, too, as the beaver and the muskrat, have a decided economic value as fur bearers; while some, as the rabbits and the tree squirrels, afford sport in hunting and are useful as human food.

The noxiousness of rodents depends largely upon the locality in which they live and upon their relation to man and his interests. All are chiefly vegetarian in diet and by reason of their rapid reproduction are capable of becoming pests; but it is only when they are actively injurious that means of control are needed.

Probably no term applied to animals has been so generally misused as the word "vermin." Originally restricted to small creeping animals, wormlike in their movements, and especially to insects, the term has been broadened by English gamekeepers to include all enemies of ground game. Usage now sometimes applies the term to all animals that are supposed to be either harmful or useless. Writers on game protection are often vehement in their condemnation of "vermin," forgetting that what may be so considered by one person may from the standpoint of another be highly useful. The interests of the sportsman or gamekeeper often run counter to those of his farmer neighbor, and they frequently clash on such matters as rabbit protection and the enforcement of trespass laws. A better understanding of the habits of birds and mammals, especially of their food and the interrelation of species that prey and are preyed upon, will greatly restrict the number of animals that may properly be called "vermin." Under natural conditions few can rightly be so designated; but man has interfered with nature until he has disturbed its balance. He has introduced artificial conditions and so changed the environments of animals that some have prospered while others have been driven out. The species that have been most favored by man's activities are, unfortunately, those that have been most harmful to his interests. As a result he must now make warfare upon foes that were once inoffensive.

HARMFUL NATIVE RODENTS.

Only four of the many forms of wild rodents found within the United States have been introduced; the others are indigenous to the country. Among harmful native rodents are included the short-tailed field mice, white-footed mice, cotton rats, kangaroo rats, pocket gophers, ground squirrels, prairie-dogs, woodchucks, and rabbits. A few others occasionally do slight damage to crops or other property.

SHORT-TAILED FIELD MICE.

Several groups, or genera, of short-tailed field mice occur in the United States and Canada, but only two of them have, by reason of their abundance in cultivated regions, become serious pests. These are commonly known as meadow mice[1] and pine mice[2] (fig. 1).

Meadow mice are widely distributed, inhabiting most parts of the Northern Hemisphere. In the United States we have many species, but, fortunately, have thus far had no widespread plagues of the animals like those that have occurred abroad. However, there have been many local outbreaks, notably that of 1907–8 in the Humboldt Valley, Nevada, where much of the alfalfa crop was utterly ruined. Fortunately, few of our species come in contact with farm operations, but these few sometimes multiply enormously and inflict heavy damage by attacking and girdling fruit trees and by destroying other crops. Their presence is indicated by their many surface trails under dead grass, weeds, or other trash. The animals usually avoid open spaces, where they are exposed to such enemies as hawks and owls, birds which make these mice the chief part of their diet.

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[1] Genus *Microtus*.

[2] Genus *Pitymys*.

Depredations by meadow mice may be greatly lessened and serious outbreaks prevented by clean cultivation, the elimination of old fence rows, and the prompt burning of dead weeds and other trash.

Pine mice, like moles, burrow underground, where their tunnels are similar in extent and intricacy to the surface runways of meadow mice; but as their natural habitat is the woods, they come less frequently in contact with farm crops. Their most serious depredations are in orchards, although they often do great damage in lawns and plantations adjacent to woodlands by eating bulbs and gnawing the roots of shrubbery. In such situations they also frequently destroy potatoes, peanuts, and newly planted seeds of truck crops. Their concealed operations permit them to do much harm before their presence is suspected. For this reason, also, they are less often the victims of birds of prey.

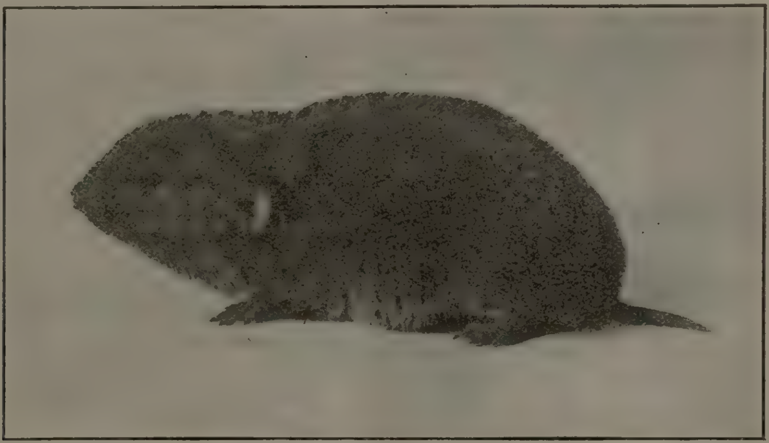

FIG. 1.—Pine mouse.

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Ordinary mouse traps of the guillotine type, baited with rolled oats and set in runways of either meadow or pine mice, will free a small area of the animals (fig. 2); but for large areas or for operations against considerable numbers of these mice, poisons are more effective.

For poisoning meadow mice on large areas the following methods are recommended:

Dry-grain formula.—Mix thoroughly 1 ounce powdered strychnin (alkaloid), 1 ounce powdered bicarbonate of soda, and ⅛ ounce (or less) of saccharin.

Put the mixture in a tin pepperbox and sift it gradually over 50 pounds of crushed wheat, or 40 pounds of crushed oats, in a metal tub, mixing the grain constantly so that the poison will be evenly distributed. Dry mixing has the advantage that the grain may be kept any length of time without fermentation. If it is desired to moisten the grain to facilitate thorough mixing, it will be well to use a thin starch paste (as described below, but without strychnin) before applying the poison. The starch soon hardens, and fermentation is not likely to follow.

If crushed oats or wheat can not be obtained, whole oats may be used, but they should be of good quality. As mice hull the oats before eating them, it is desirable to have the poison penetrate the kernels. A very thin starch paste is recommended as a medium for applying poison to the grain. Prepare as follows:

Wet-grain formula.—Dissolve 1 ounce of strychnin (sulphate) in 2 quarts of boiling water. Dissolve 2 tablespoonfuls of laundry starch in ½ pint of cold water. Add the starch to the strychnin solution and boil for a few minutes until the starch is clear. Pour the hot starch over 1 bushel of oats in a metal tub and stir thoroughly. Let the grain stand overnight to absorb the poison.

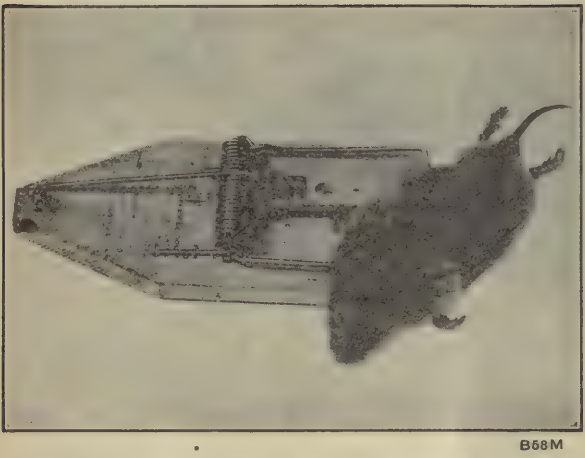

FIG. 2.—Meadow mouse caught in guillotine trap.

The poisoned grain prepared by either of the above formulas is to be distributed over the infested area, not more than a teaspoonful at a place, care being taken to put it in mouse runs and at the entrances to burrows. To avoid destroying birds it should whenever possible be placed under such shelters as piles of weeds, straw, brush, or other litter, or under boards. Small drain tiles 1½ inches in diameter have sometimes been used to advantage to hold poisoned grain, and old tin cans with the edges bent nearly together will serve the same purpose.

Chopped alfalfa hay poisoned with strychnin was successfully used to destroy meadow mice in Nevada during the serious outbreak of the animals in 1907–8:

Alfalfa formula.—One ounce of strychnin (sulphate) dissolved in 2 gallons of hot water was found sufficient to poison 30 pounds of chopped alfalfa previously moistened with water.

This bait, distributed in small quantities at a place, was very effective against the mice and did not endanger birds.

For poisoning mice in small areas, as lawns, gardens, seed beds, vegetable pits, and the like, a convenient bait may be prepared from ordinary rolled oats, as follows:

Oatmeal formula.—Dissolve $\frac{1}{16}$ ounce of strychnin in 1 pint of boiling water and pour it over as much oatmeal (about 2 pounds) as it will wet. Mix until all the grain is moistened. Put it out, a teaspoonful at a place, under shelter of weed and brush piles or wide boards.

The poisoned oatmeal is adapted for killing either meadow or pine mice, but for the latter sweet potatoes, prepared as follows, have proved even more effective:

Potato formula.—Cut sweet potatoes into pieces about the size of grapes. Place 3 quarts of these cut baits in a pan or bucket, and from a tin pepperbox slowly sift over them $\frac{1}{8}$ ounce of powdered strychnin mixed with an equal quantity of baking soda, stirring constantly so that the poison is evenly distributed. Poison should be applied as soon as potatoes are cut and bait should be put out while fresh.

The bait, whether of grain or pieces of potato, may be dropped into the pine mouse tunnels through the natural openings or through holes made with pieces of broom handle or other stick. Bird life will not be endangered by baits thus placed.

WHITE-FOOTED MICE.

White-footed mice, or deer mice,[1] are of many species and are present in almost all parts of the country. They live in fields and woods, and while they feed on grain to some extent, they rarely are present on cultivated lands in sufficient numbers to do serious harm. Occasionally they invade greenhouses or hotbeds and destroy seeds or sprouting plants. In the seed beds of nurserymen, and especially in those of the forester who tries to grow conifers, they often do much injury. They are, in fact, the most serious pests known to the conifer nurseries of the Forest Service.

In ordinary places white-footed mice may be readily poisoned by the methods recommended for meadow and pine mice. Unfortunately the seed of the pine is the favorite food of these animals and where it is planted in abundance they refuse to take grain baits. Crushed pine seeds poisoned with strychnin by the "wet-grain formula," given above, have proved effective in such places. Preliminary poisoning of these mice on areas to be seeded to pine is highly recommended. For seed beds, poisoning on surrounding areas two or three times a year will usually prevent the approach of mice and give immunity to the planted seeds.

COTTON RATS.

In parts of the Southern States a large native mouse, or rat, commonly known as the cotton rat[2] (fig. 3), often becomes a field pest.

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[1] Genus *Peromyscus.*

[2] Genus *Sigmodon.*

Of some 28 known forms of this animal, 7 occur north of Mexico, in Texas, New Mexico, Arizona, Oklahoma, and southern Kansas and along the Gulf coast from Louisiana to Florida.

Cotton rats damage growing crops to some extent, but are especially destructive to grain in shocks. In many of their habits they are similar to meadow mice, and they multiply fully as fast. They chiefly inhabit weedy borders and areas covered with old grass, where they are sheltered from enemies. They do not often attack the bark of trees, but, being larger than meadow mice, are capable of destroying much more grain in a short time. They ruin melons and other truck crops and have been a serious pest to date growers in Arizona.

Cotton rats are easily poisoned by the same methods recommended for destroying meadow mice.

Fig. 3.—Cotton rat (dead) and nest, Pecos Valley, Tex.

KANGAROO RATS.

Fifty-nine known species and races of the kangaroo rat (fig. 4), belonging to three groups, inhabit North America, and 45 of them occur north of Mexico. Two groups[1] are widely distributed in the West; they differ in anatomical characters, but are much alike in general appearance and habits. A third group[2] includes three species and one race of very small animals, all of which are rather restricted in range and of slight economic importance. Kangaroo rats are gentle, easily tamed, and make sprightly and interesting pets. They live mostly in deserts, sagebrush country, and sandy places and are harmless until pioneer agriculture is pushed into these regions. They feed to some extent on green vegetation, but mainly on seeds. As they do not hibernate, they lay up large stores of winter food in their burrows. They are gregarious but, being noctural in their activities, are seldom seen by day.

In the sand-hill and sagebrush country of the West there is much complaint of destruction of pioneer crops by kangaroo rats. The areas first cultivated are usually small, and the animals sometimes destroy an entire crop. Where corn is planted they take all the seed, securing not only food for present use, but storing in their caches large quantities for the future. They are destructive to other grains also and dig up newly planted melon and other seeds. Vegetable gardening is an impossibility where kangaroo rats are abundant. The choice is between making warfare on and destroying the animals or abandoning cultivation. Fortunately they take poisoned grain readily and are easily trapped with baits of this kind. The poison recommended for prairie-dogs is well adapted to destroy kangaroo rats. Trapping with guillotine traps, although successful, is usually too slow to be practicable.

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[1] *Perodipus* and *Dipodomys*.

[2] Genus *Microdipodops*.

In some instances farmers in the sand-hills of the West prevent depredations by kangaroo rats and succeed in growing crops of corn by stirring the seed in hot water in which there has been mixed enough coal tar to coat the grain slightly. A large spoonful of coal tar to a gallon of boiling water is used. When the mixture has cooled somewhat the corn may be stirred in and allowed to remain several minutes without danger to germination.

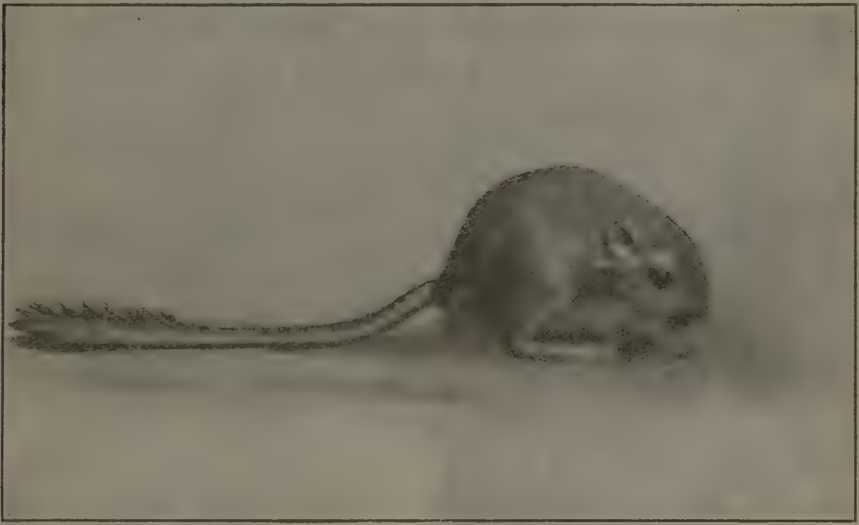

FIG. 4.—Kangaroo rat, adult, one day after capture.

POCKET GOPHERS.

Pouched rats, commonly called pocket gophers (fig. 5), are among the most serious of rodent pests in most of the States west of the Mississippi River. They occur also in parts of Georgia, Alabama, and Florida, in the greater part of Illinois, and in southern Wisconsin. Outside the United States they are abundant southward in many parts of Mexico and Central America, and northward in northwestern Canada to Winnipeg and the Saskatchewan Valley.

Nine groups, or genera, of pocket gophers are recognized, but only three of them occur north of Mexico. Two of these[1] have a very wide distribution. They include many species and varieties, all nearly similar in habits and alike destructive. Many forms inhabit mountains and deserts, where they do not injure agriculture. Others, however, live in the richest alluvial soils, where they are destructive to all crops.

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[1] *Geomys* and *Thomomys*.

Pocket gophers do harm in many ways. They eat growing grain and cover much of it with soil. In digging burrows they cause loss of hay by throwing up mounds which prevent close mowing. These mounds also injure much machinery. Their burrows admit surface water and aid it to wash out deep gullies on sloping land. By piercing dams and embankments the tunnels cause costly breaks. The animals ruin gardens and injure field crops. In addition to this they kill trees in orchards and in forest plantings by gnawing off the roots.

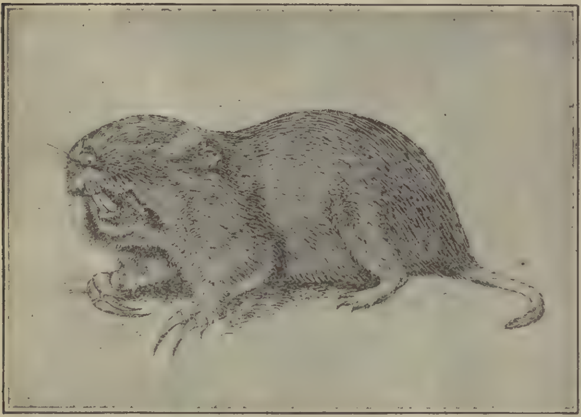

FIG. 5.—Pocket gopher.

Two practical methods of killing pocket gophers are always possible—trapping and poisoning. The first method is slow, but very effective on small areas or where but few pocket gophers are present; the other is the better plan on large fields and for cooperative work on adjacent farms. While the ordinary steel trap may be used successfully for pocket gophers, much better results can be obtained with the special traps for these animals commonly on the market (fig. 6).

In irrigated districts, where water is available, flooding the land will drive out the animals, and they may be killed by men and dogs. Fumigation of the burrows with carbon bisulphid or with sulphur smoke, while often recommended as a means of destroying pocket gophers, has been found extremely uncertain and costly.

Poison for pocket gophers.—Cut sweet potatoes or parsnips into pieces with the largest diameter less than an inch. Wash and drain 4 quarts of the cut baits. Place in a metal pan, and from a pepperbox slowly sift over the dampened baits $\frac{1}{8}$ ounce of powdered strychnin (alkaloid) and one-tenth as much saccharin (well shaken together or ground together in a mortar), stirring to distribute the poison evenly.

Tunnels of pocket gophers, which are usually from 3 to 8 inches below the surface of the ground, may be readily located by means of a probe. Any blacksmith can make one by affixing a metal point

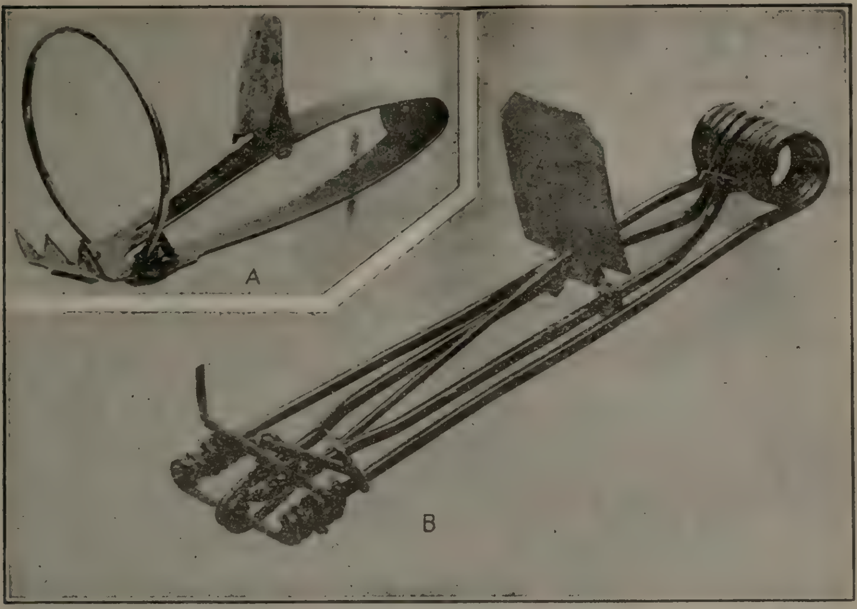

FIG. 6.—Types of special pocket-gopher traps.

to a shovel or spade handle and attaching an iron foot rest about 15 or 16 inches above the point. By forcing this instrument into the soil near the pocket-gopher workings, or a foot or two back of fresh mounds, one can feel the open tunnel as the point breaks into it. The hole may be enlarged and its sides made firm by pressing the soil laterally with the probe. A bait or two should be dropped into the tunnel and the probe hole covered. Care should be taken to place the baits in the main tunnels rather than in the short laterals leading to mounds. Different forms of probes have been used successfully by the Biological Survey in its demonstration work. Two of the better kinds are illustrated in figure 7.

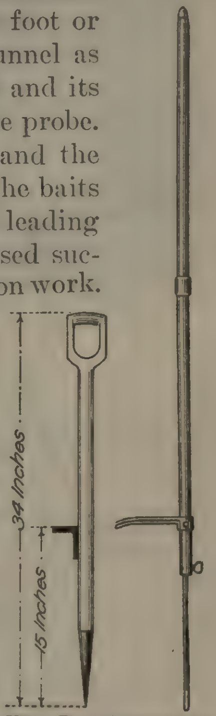

FIG. 7.—Convenient probes for locating pocket-gopher runs.

GROUND SQUIRRELS.

More than 50 species and races of ground squirrels, or spermophiles,[1] inhabit the United States and Canada, and some of them are so numerous in agricultural regions as to be a constant menace to the crops. The spermophiles comprise a group of long, slender animals, of grayish or grayish-brown color—sometimes mottled or striped—and with a medium or long tail, usually less bushy than that of the larger of the tree squirrels. These ground squirrels are often, but wrongly, called "gophers" and are locally named "digger" squirrels and "picket pins." They inhabit mainly open plains, mountain valleys, and borders of wet meadows, but are found also in open places in the forests and sometimes high up the slopes of mountains. They dig numerous deep burrows and are very destructive to nearly all crops (figs. 8 and 9), eating both the growing plants and the ripe or ripening grain. In irrigated districts the animals burrow in embankments (fig. 10) and levees and are almost as troublesome as pocket gophers.

---

[1] Genus *Citellus*.

Among the largest and most destructive of these animals is the California, or "digger," ground squirrel.[1] It is gray in color and has a long, rather bushy tail. It occurs in the Southwest and West from western Texas to California and Oregon.[2] In parts of California the race known as the Beechey ground squirrel is especially abundant and menaces not only crops and irrigation ditches, but also human life, in that it is a known carrier of bubonic plague. About a dozen cases of this disease among human beings have been traced directly to this squirrel and a large number of the animals collected by the United States Public Health Service have been found infected. The Health Service, in cooperation with State authorities, has succeeded in establishing south and east of San Francisco, in the

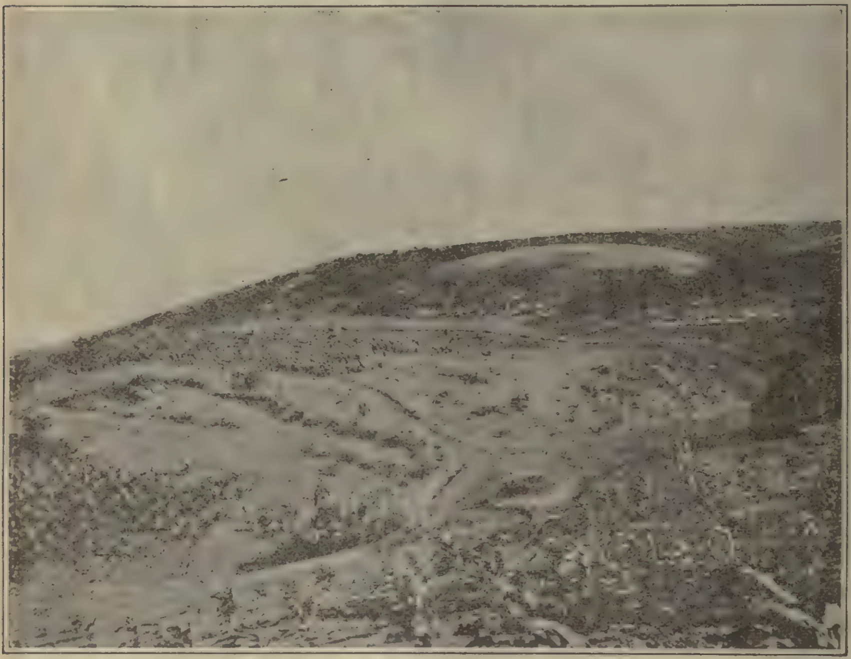
B9141

FIG. 8.—Cornfield ruined by Columbia ground squirrels (see title-page illustration).

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[1] *Citellus beecheyi beecheyi* and related races.

[2] Including the closely related *Citellus grammurus*.

counties that were the center of infection, a wide zone now comparatively free from squirrels. The Department of Agriculture, through the Bureau of Biological Survey, has exterminated most of the squirrels in the national forests that lie near the plague-infected counties. It is probable that all immediate danger of an outbreak of human plague by infection from ground squirrels has passed.

Another large and destructive species is the Columbia ground squirrel[1] (see illustration on title-page). It occurs within the United States in parts of Montana, Idaho, eastern Washington, and eastern Oregon. While it inhabits chiefly the river valleys, it has been taken in Montana on mountains near timberline. Where grain is grown in the narrow valleys and in the important wheat districts of eastern Washington this species is extremely injurious. Early attempts to destroy it by poison proved unsuccessful, because the animal is able to resist much larger doses of strychnin than are needed to kill other ground squirrels.

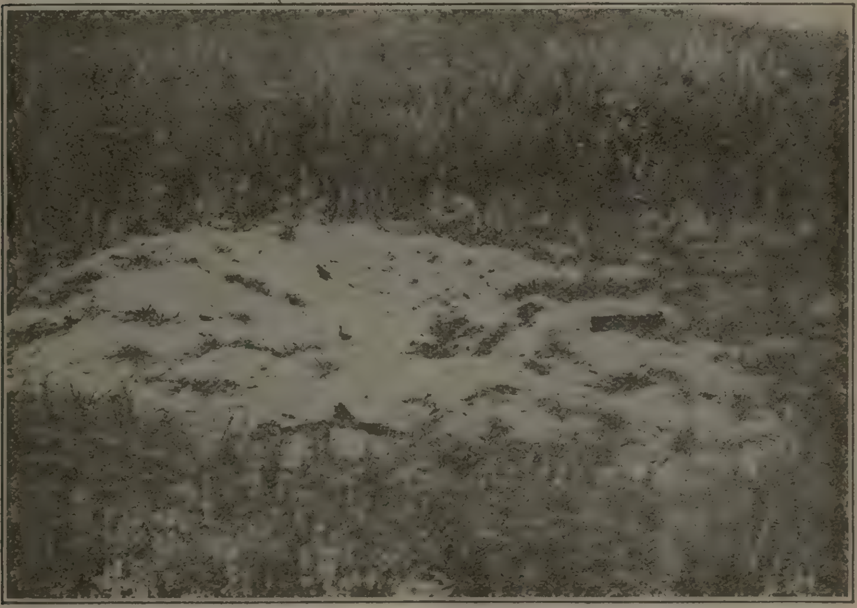


Fig. 9.—Mound of California ground squirrel in oats field. B11132

A destructive and widely distributed species is the Richardson ground squirrel.[2] In its larger form it is found in much of Montana, the Dakotas, and northward into Canada. A somewhat smaller race (*elegans*) is found in southeastern Oregon, northern Nevada, southern and eastern Idaho, southern Wyoming, and northern Colorado. This spermophile is very destructive to crops, especially to grain, and within its range warfare against it is absolutely necessary to successful farming.

---

[1] *Citellus columbianus.*

[2] *Citellus richardsoni richardsoni* and *Citellus richardsoni elegans.*

The striped ground squirrel,[1] the Franklin ground squirrel,[2] and some other species, which are less gregarious and seldom occur in great numbers in any locality, are less destructive than any of the three groups named. Other species are nearly as injurious as those described. The animals have been dealt with in three groups, because slightly different formulas for poisoning each of them have been worked out by field investigators of the Biological Survey. The formula for the Richardson ground squirrel is adapted for all the species except the Columbia and the California forms.

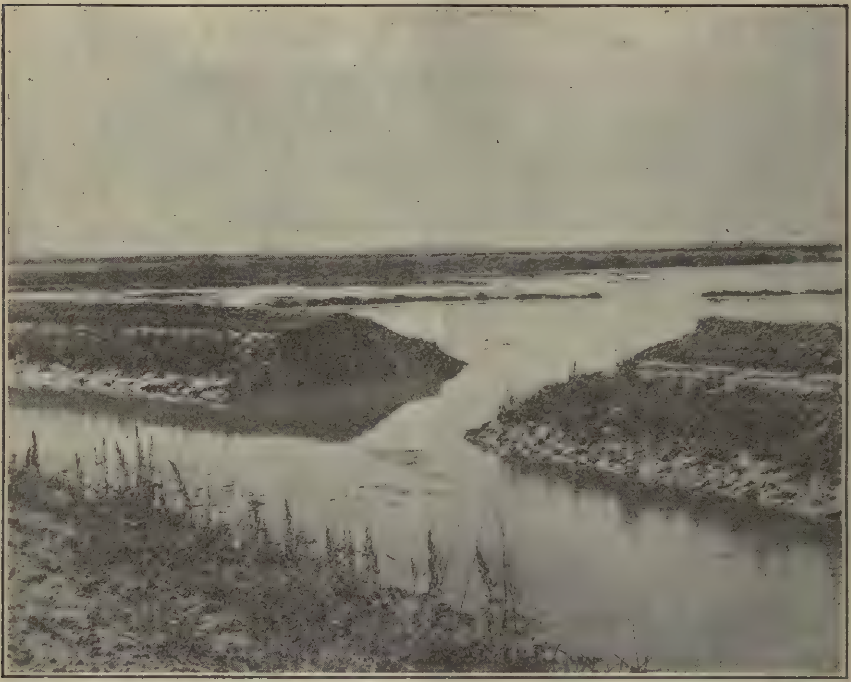


FIG. 10.—Break in irrigation ditch (lateral) caused by burrowing of California ground squirrel. Six acres of alfalfa ruined.

Poison for Columbia ground squirrels.—Mix 1 ounce of powdered strychnin (alkaloid), 1 ounce of powdered bicarbonate of soda, 1 teaspoonful of saccharin, and ½ pound of dry powdered laundry starch, and stir with enough cold water to make a smooth, creamy paste. Apply to 12 quarts of good, clean oats in a metal tub or other vessel, and stir thoroughly to distribute the poison evenly. When the poisoned grain is dry scatter it along squirrel trails or on hard soil on the surface near the squirrel burrows. A quart of the grain should make 40 to 50 baits, and if properly distributed stock will not be endangered by this quantity.

---

[1] *Citellus tridecemlineatus,* including several races.

[2] *Citellus franklini.*

Poison for Richardson ground squirrels.—Mix 1 tablespoonful of laundry starch in ½ teacup of cold water, and stir it into ½ pint of boiling water to make it a thin, clear mucilage. Mix 1 ounce of powdered strychnin with 1 ounce of powdered bicarbonate of soda, and stir the mixture into the hot starch, making a smooth, creamy paste free from lumps. Stir in ¼ pint of heavy corn sirup and 1 tablespoonful of glycerin, and, finally, 1 scant teaspoonful of saccharin. Apply to 20 quarts of oats, and mix thoroughly to coat every kernel. Each quart of the poisoned grain should make 40 to 60 baits. Distribute in same manner as stated for poisoning Columbia ground squirrels.

Poison for California, or "digger," ground squirrels.—Prepare by same formula as for Richardson ground squirrels, but use 16 quarts of clean barley instead of oats. Distribute as for poisoning Columbia ground squirrels.

These poisons may be used at any time of the year when the squirrels are active. The Biological Survey has had excellent results with them, even in midsummer. Trapping is too slow a process to use effectively against large colonies of ground squirrels.

PRAIRIE-DOGS.

FIG. 11.—Prairie-dog.

B 14282

The prairie-dog[1] (fig. 11) of the Great Plains needs little description. It is widely distributed on the plains east of the Rocky Mountains, from northern Mexico almost to the Canadian border. Several other forms occupy the mountain valleys and parks westward. All live in thickly populated colonies, or "towns," and subsist on vegetation. They often take fully half the pasturage on the ranges and greatly reduce the carrying capacity for live stock (fig. 12). Several Western States have attempted to provide for the extermination of prairie-dogs through legislative enactments; and in some of them, notably Kansas, the pest has greatly decreased. Within the national forests settlers have complained of inability to cope with the animals, because their lands when freed from prairie-dogs are reinfested from the surrounding Government lands. For this reason and for range improvement the Department of Agriculture has undertaken systematic extermination work within the forests and has already succeeded in freeing large areas of these animals.

---

[1] *Cynomys ludovicianus.*

Trapping is too slow a method for exterminating prairie-dogs, and fumigation is too expensive. As in the case of ground squirrels, strychnin has proved to be the most satisfactory poison. Oats of the best quality obtainable should be used as bait. It has been found that prairie-dogs take this grain readily, even when green food is abundant. Wheat is well adapted for winter poisoning, and in the South, where heavy oats are rarely obtainable, milo or feterita is an excellent substitute.

Poison for prairie-dogs.—Mix thoroughly 1 ounce of powdered strychnin (alkaloid) and 1 ounce of common baking soda (bicarbonate). Dissolve 1 heaping tablespoonful of dry laundry starch in a little cold water and add it to ¾ pint of boiling water. Boil and stir until a thin, clear paste is formed. Slowly sift the mixture of strychnin and soda into the starch paste, stirring constantly to form a smooth, creamy mass. Add ¼ pint of heavy corn sirup and 1 tablespoonful of glycerin, and stir. Add $\frac{1}{10}$ ounce of saccharin, and again stir thoroughly. Pour this mixture while still hot over 13 quarts of clean oats and mix until all the grain is coated.

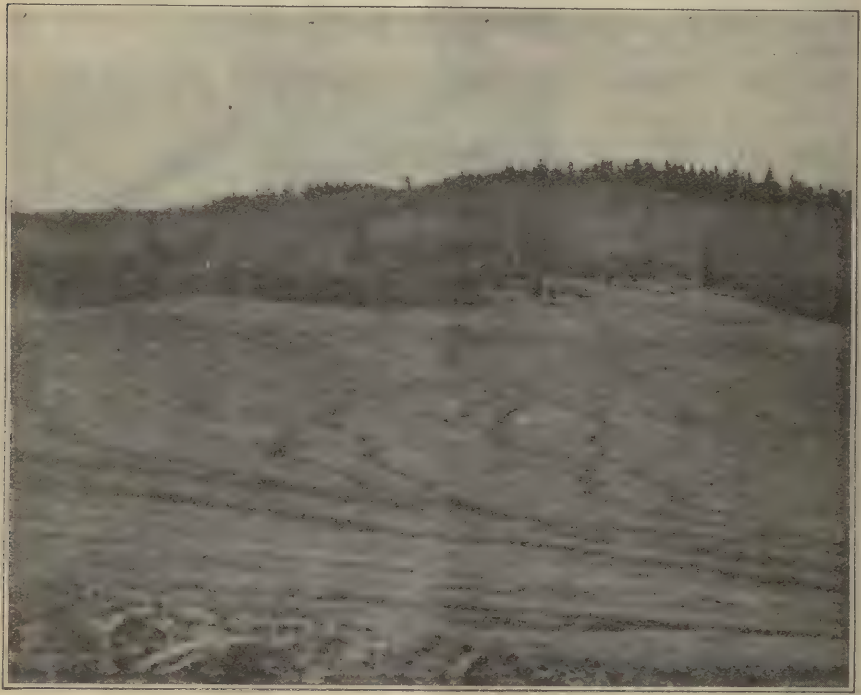


FIG. 12.—Erosion following the destruction of grass by prairie-dogs. B14233

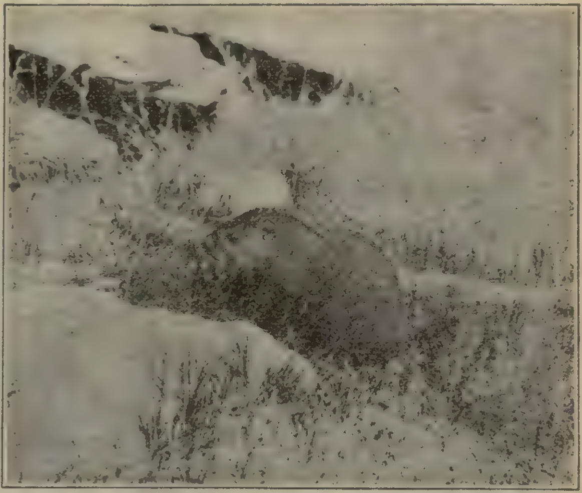
If alkaloid strychnin is not available, the sulphate may be used, either powdered or in crystals, but it is necessary to vary the formula. Dissolve the strychnin in the boiling water before adding the cold starch. After the poisoned starch paste is clear, stir in the soda very slowly. Then add the sirup, glycerin, and saccharin as in the above directions and mix with the grain.

For mixing small quantities an ordinary metal washtub is convenient. For large quantities a tight, smooth box may be used, and the mixing done with a hoe or spade.

Each quart of the prepared grain is sufficient to treat about 50 prairie-dog burrows. Scatter the grain on clean, hard ground near the mounds or burrows, never on loose soil or in the holes. With reasonable care, cattle, sheep, or other live stock on the range will not be endangered.

This poison is effective at any season when prairie-dogs are active, but, on the whole, early spring or a time of drought, when green food is scarce, is preferred for poisoning operations. In the South, or wherever the animals do not hibernate, winter poisoning is recommended. The cost of complete extermination of the animals, including labor, need not exceed 4 or 5 cents an acre.

WOODCHUCKS.



B18056

Fig. 13.—Woodchuck, known also as marmot and ground-hog.

The woodchuck, or ground-hog, is the largest of our marmots. The common woodchuck (fig. 13)[1] inhabits eastern North America from northern Georgia and middle Alabama northward, including the greater part of Canada. In the United States it ranges westward to Arkansas, eastern Kansas, and eastern Minnesota. In Canada it is found as far north as Great Slave Lake and westward to the base of the Rocky Mountains. Another species of woodchuck[2] inhabits the higher country of the Black Hills, Rocky Mountains, Sierra Nevada, Cascades, and other ranges in the West. This mountain form seldom comes in contact with agriculture, but the eastern species frequently damages garden vegetables, clover, and other crops. Also, its burrows and mounds interfere with mowing and other farm operations. In some States the animal is regarded as so obnoxious that local bounties are paid for destroying it.

Woodchucks, while somewhat gregarious, seldom occur in large colonies, and may, therefore, be kept in check by shooting or trapping. They may be poisoned by strychnin inserted in pieces of sweet apple, carrot, or sweet potato. The animals are often destroyed in their burrows by fumigation with carbon bisulphid or by the discharge of blasting powder.

---

[1] *Marmota monax monax* and several geographic races.

[2] *Marmota flaviventris flaviventris* and nearly a dozen races.

To destroy woodchucks with carbon bisulphid, saturate a wad of cotton or waste with about 1½ ounces of the liquid. Place the cotton well inside the woodchuck burrow and close the opening with a piece of sod, well stamped down. If there are two or more entrances to a burrow, all but one should be tightly closed before fumigation.

RABBITS.

The smaller forms of rabbits, known generally as cottontails,[1] are useful animals and become objectionable only when too numerous in the vicinity of orchards or nurseries. The same is true of the larger snowshoe rabbits.[2] The jack rabbits[2] of the West are of less value for human food, and, by reason of their abundance in newly settled regions, often interfere greatly with crops and the growing of orchard and other trees.

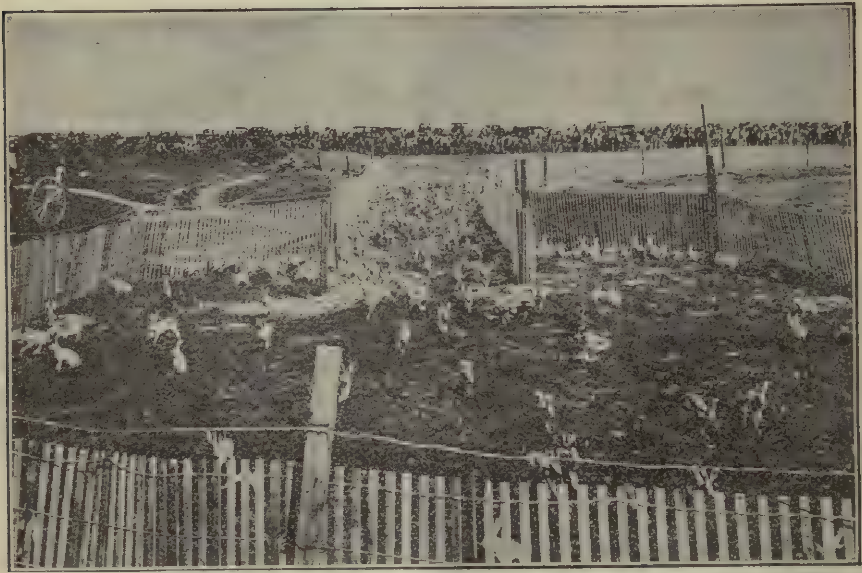

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FIG. 14.—An organized rabbit drive. Community cooperation in hunting jack rabbits gives very good results in rendering the numbers of these animals, everywhere regarded as a pest.

Jack rabbits are not protected in any of the States, but are everywhere regarded as a pest. They afford considerable sport in coursing with fleet greyhounds, and at times become so abundant and destructive that entire communities unite to kill them by the organized hunt or drive (fig. 14). A large area is surrounded, and the animals are driven toward some central point, where a wire corral has been built, into which, with the help of wing barriers, thousands of rabbits are driven and then slaughtered. When these hunts take place in cold weather the rabbits are usually shipped to large cities, where the carcasses may be sold to canning establishments, distributed to public charities, or otherwise used to supplement the meat supply.

---

[1] Genus *Sylvilagus*.

[2] Genus *Lenus*.

Many of the States which have a close season for cottontail or other native rabbits permit landowners at any time to protect property from the depredations of the animals. Usually, however, close hunting and trapping in the open season afford ample protection, and only in exceptional cases is it necessary to resort to other measures for relief.

Except where deep snows fall, orchards or other crops on small areas may be protected by the use of rabbit-proof fencing. Individual trees may be safeguarded by metal or wooden protectors attached to the trunks. In Idaho a poisoned wash of strychnin, glycerin, and starch proved effective to save trees from jack rabbits, and the method is recommended for trial in any locality where conditions warrant its use. The wash is prepared as follows:

Poison wash.—Dissolve 1 ounce of strychnin (sulphate) in 3 quarts of boiling water. Dissolve ½ pound of laundry starch in 1 pint of cold water, stirring thoroughly. Pour the starch into the vessel containing the strychnin and boil the mixture a short time until the starch is clear. Add 6 ounces of glycerin and stir. When the paste is cool enough apply to tree trunks with a paint brush.

The mixture adheres well and forms a thin coating. If rabbits attack the tree they will be killed before they can seriously injure it. The wash should not be used if live stock, especially young cattle, have access to the orchard.

For poisoning jack rabbits in winter the following formula is recommended:

Poison baits.—Good oats, 12 quarts; powdered strychnin, 1 ounce; laundry starch, 1 tablespoonful; soda (bicarbonate), 1 ounce; saccharin, ⅛ ounce; water, 1 quart. Prepare as directed for mixing prairie-dog poison. Not over a tablespoonful of the poisoned grain should be used in a single bait, and this should be scattered considerably. A little alfalfa hay may be used to attract rabbits to the grain. The poison is especially effective when snow covers the ground.

Partly ripened or ripe heads of barley or wheat soaked in a sweetened solution of strychnin or coated with the starch-strychnin paste just described have also proved effective bait for rabbits, but care must be exercised in using them, as they are likely to be eaten by live stock.

OTHER NATIVE RODENTS.

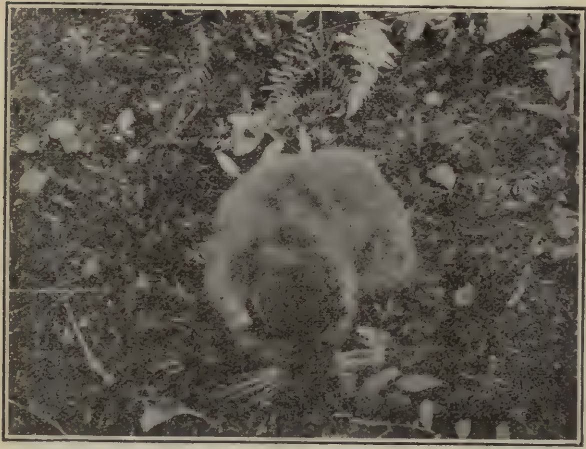
Other native rodents that occasionally damage crops or other property are the muskrat, mountain-beaver (fig. 15),[1] woodrats,[2] tree squirrels, chipmunks, and perhaps some species of native mice not already mentioned. Muskrats are valuable fur animals and should not be destroyed unless they are doing material damage not otherwise preventable. They are easily trapped or may be poisoned by feeding them pieces of carrot, sweet apple, or sweet potato in which strychnin has been placed.

---

[1] Genus *Aplodontia*.

[2] Genus *Neotoma*.

Mountain-beavers in the United States are restricted to the coastal region of Washington, Oregon, and California, and to the Sierra Nevada in the last-named State. Their habitat does not often bring them in contact with agriculture, but in western Washington considerable complaint of their depredations on crops, particularly small fruits, has been made. The animals may be readily poisoned with apples in which strychnin has been placed.



B15902

FIG. 15.—Mountain-beaver, or sewellel, a pest in parts of the Northwest.

Squirrels, chipmunks, and native mice not previously mentioned rarely do serious damage. If any become troublesome locally, shooting, trapping, or the use of poisons herein recommended for other rodents will prove satisfactory means of relief.

INTRODUCED RODENTS.

The house mouse and three kinds of rats are the only rodent pests in North America not native to the country. They are our most injurious rodents, however, and probably inflict greater losses than do all the native species combined.[1]

House mice are easily trapped or poisoned, but poison is not suited for use in occupied dwellings. Traps, however, are sufficiently effective for clearing the premises of these pests. The ordinary small guillotine traps are recommended. They should be set as lightly as possible and baited with oatmeal (rolled oats). A few grains should be placed on the trigger pan and a little more in the vicinity and close to the trap. Persistent trapping will soon clear an ordinary dwelling of mice.

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[1] For a full discussion of these rodents, see Farmers' Bulletin 896, "House Rats and Mice," 1917.

Rats are much more suspicious than mice and are rather hard to trap or poison. Either method of destroying them may be made effective by making inaccessible all food other than the baits used. The importance of rat-proofing buildings in extensive operations against these pests should not be overlooked; and much loss may be prevented by rat-proofing all containers of stored grains and food products. No one kind of poison can be relied upon to be effective under every circumstance. In general, poisons can not be used in occupied dwellings without disagreeable results, for no poison will prevent decomposition of dead bodies of rats. Inside of residences, therefore, traps must be the main reliance. Simple traps of the guillotine type are recommended as best. Baits should be varied to suit local conditions—in meat markets grains are recommended, and where grain is stored meat and fish are more effective.

Some cats and some dogs are useful against rats, but the well-fed and pampered feline or canine will refuse to hunt them. Ferrets are of no use in rat catching unless handled by an experienced person helped by trained dogs. Rat viruses seldom prove satisfactory, and in occupied premises are open to the same objections that hold against poisons; besides, they are much more expensive.

Under most circumstances the best results in ridding premises of rats may be obtained by the use of a sufficient number of ordinary guillotine traps. Oatmeal is recommended for bait, but fish, bacon, sausage, and even pastry or cheese are sometimes useful as alternatives. Traps should be set lightly, and all food other than baits should be covered or made inaccessible. Traps may be placed in runs, behind furniture or boards leaned against the walls, or at the entrances to rat holes. As they are often sprung when rats run over them, they need not always be baited. It is needless to say that in order to succeed, the trapper must take an interest in his work and attend closely to every detail.

RELATION OF CARNIVOROUS ANIMALS TO RODENTS.

Most carnivorous, or flesh-eating, animals feed extensively on the rodent pests of the farm. Coyotes, foxes, wildcats, badgers, skunks, minks, and other flesh-eating mammals are among the most potent agents in preventing an undue increase of mice, ground squirrels, pocket gophers, and the like; and much of the damage now done by rodents is due to the unceasing warfare that has been waged against their enemies, the carnivorous animals. These have been hunted, not only for their valuable pelts, but because they are considered the enemies of domestic animals and game. The fact that many of them destroy far more noxious rodents than they do useful animals has often been forgotten, and, in the name of game protection, legislatures have sometimes proscribed by bounties species that do far more good than harm. As a matter of fact many of our fur animals are an asset to the country, equally as valuable as our game, and experience has often proved that their destruction is no real help to game conservation.

Birds of prey, including eagles, hawks, and owls, may be included in the list of flesh-eating animals that on the whole are more useful than harmful, because their chief economic function is to destroy noxious rodents. A few species of hawks that feed mainly on small birds should be considered noxious, but this should not lead to warfare against hawks as a class. In almost every instance of depredation on poultry by either bird or mammal, the individual and not the species is the offender. Punishment should, therefore, be directed against the individual. It is within the law in many States for the farmer to kill an animal that destroys his property; but it is unjust to carry on an offensive campaign against all hawks or all minks because one has been a marauder on poultry. The payment of money from the public treasury in a general warfare against certain hawks or owls is especially open to danger, in that the public does not distinguish between species, and the useful ones are often the ones to be destroyed.

Snakes also are extremely useful in controlling the numbers of rodents. That very few snakes are venomous is too often forgotten, and all species are wantonly destroyed. People throughout the country should acquaint themselves with the habits of snakes and learn the folly of killing them; farmers, especially, should do all in their power to protect the harmless kinds.

COOPERATION IN CONTROLLING RODENTS.

Any farmer may by care and industry free his own premises of harmful rodents, but he is helpless to prevent an early recurrence of the trouble unless he can secure the active cooperation of his neighbors.[1] Only by unity of effort can an entire county or township be freed of any kind of rodent that may inflict losses on crops or other property. By combining to hire labor and purchase poison the cost of treatment may be materially reduced, and when permanance of results is considered there can be no question of the economy of such cooperation. It is urged, therefore, that wherever possible the destruction of rodent pests be made a community undertaking.

In the past, individual efforts, often supplemented by the payment of bounties by State, county, or township, have accomplished so little to reduce rodent depredations that other methods are now required. In many western counties the sum paid out in a single year for bounties on pocket gophers or ground squirrels would, if wisely expended in poisoning operations, secure the destruction of every such animal in the county and make unnecessary any further outlay for the purpose. The bounty system affords no permanent relief from rodent pests and entails heavy taxation as long as it is continued.

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[1] Cf. Separate No. 724, from the Yearbook of the Department of Agriculture for 1917, entitled "Cooperative Campaigns for the Control of Ground Squirrels, Prairie-Dogs, and Jack Rabbits," by W. B. Bell.

The Bureau of Biological Survey has developed effective methods of destroying field mice, pocket gophers, ground squirrels, prairie-dogs, and other noxious rodents. These have been applied over wide areas and their effectiveness fully demonstrated. The work has been done on public lands by the bureau alone or elsewhere in cooperation with other bureaus or with State or county authorities. A wide extension of these activities is planned, and correspondence or conference on the subject is invited.

PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE RELATING TO NOXIOUS MAMMALS.

AVAILABLE FOR FREE DISTRIBUTION.

How to Destroy Rats. (Farmers' Bulletin 369.)
The Common Mole of Eastern United States. (Farmers' Bulletin 583.)
Field Mice as Farm and Orchard Pests. (Farmers' Bulletin 670.)
Cottontail Rabbits in Relation to Trees and Farm Crops. (Farmers' Bulletin 702.)
Trapping Moles and Utilizing Their Skins. (Farmers' Bulletin 832.)
House Rats and Mice. (Farmers' Bulletin 896.)
Cooperative Campaigns for the Control of Ground Squirrels, Prairie-Dogs, and Jack Rabbits. (Separate 724, Yearbook for 1917.)
The House Rat: The Most Destructive Animal in the World. (Separate 725, Yearbook for 1917.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Some Common Mammals of Western Montana in Relation to Agriculture and Spotted Fever. (Farmers' Bulletin 484.) Price 5 cents.
Meadow Mice in Relation to Agriculture and Horticulture. (Separate 388, Yearbook 1905.) Price 5 cents.
Pocket Gophers as Enemies of Trees. (Separate 506, Yearbook 1909.) Price 5 cents.
The Jack Rabbits of the United States. (Biological Survey Bulletin 8.) Price 10 cents.
Coyotes in Their Economic Relations. (Biological Survey Bulletin 20.) Price 5 cents.
Economic Study of Field Mice, Genus *Microtus*. (Biological Survey Bulletin 31.) Price 15 cents.
Directions for the Destruction of Wolves and Coyotes. (Biological Survey Circular 55.) Price 5 cents.
Destruction of Deer by the Northern Timber Wolf. (Biological Survey Circular 58.) Price 5 cents.

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SPRAYING FOR THE CONTROL OF INSECTS AND MITES ATTACKING CITRUS TREES IN FLORIDA

W. W. YOTHERS

Entomological Assistant, Tropical and
Subtropical Fruit Insect Investigations

FARMERS' BULLETIN 933

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C. Issued March, 1918

Show this bulletin to a neighbor. Additional copies may be obtained free from the Division of Publications, United States Department of Agriculture

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UNDER FLORIDA CONDITIONS spraying is the most effective method for the control of citrus pests. In the past there have been many failures, and much money has been expended without adequate returns to the grower in better fruit and increased yields. These failures have been due to various causes, such as improper equipment, ineffective insecticides, and a lack of a proper spraying schedule.

This bulletin gives information regarding the best equipment for Florida conditions, and directions for preparing effective homemade insecticides. There is also given a spraying schedule that has proved satisfactory after several years of practical experience and such other information as will enable the grower to control citrus pests in a satisfactory manner.

Spraying improves the grades of the fruit and increases the yield of the trees out of all proportion to its cost, if the work is done properly.

SPRAYING FOR THE CONTROL OF INSECTS AND MITES ATTACKING CITRUS TREES IN FLORIDA.

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SUCCESS OF INSECTICIDES AND SPRAY SCHEDULES.

RELIABLE INSECTICIDES for the control of insects and mites attacking citrus trees in Florida have been developed and tested on a large scale. These insecticides, and the spray schedule now recommended for citrus groves, have been used with success for four years.

The best argument in favor of the sprays and spraying scheme discussed in this bulletin is to be found in the difficulty the writer has had in securing the same grove for demonstration spraying two or three years in succession. Once the owner of a grove has seen the benefits resulting from careful and well-timed spraying he refuses to accept the losses that he knows will come to him through the setting aside of blocks of trees to be left unsprayed for comparison with those sprayed.

CITRUS INSECTS AND MITES OF IMPORTANCE.

Of the total damage caused to citrus trees by insects and mites in Florida, more than 95 per cent may be attributed to six species. These are, in the order of their destructiveness, the citrus white fly (figs. 1, 2, 19),[1] the purple scale (fig. 4),[2] the rust mite (fig. 6),[3] the Florida red scale (figs. 4, 5),[4] the cloudy-winged white fly (fig. 3),[5] and the red spider or six-spotted mite.[6] There are several other pests of minor importance, such as the woolly white fly,[7] the purple mite,[8] and the chaff scale.[9] The citrus white fly, the most injurious of pests, now infests nearly all the groves of Florida, and the purple scale is found in greater or less numbers on every citrus tree.

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[1] *Dialeurodes citri* (Ashmead).

[2] *Lepidosaphes beckii* (Newman).

[3] *Phyllocoptes oleivorus* (Ashmead).

[4] *Chrysomphalus aonidum* (Linnaeus).

[5] *Dialeurodes citrifolii* (Morgan).

[6] *Tetranychus sexmaculatus* Riley.

[7] *Aleurothrixus howardi* (Quaintance).

[8] *Tetranychus citri* McGregor.

[9] *Parlatoria pergandii* Comstock.

LOSSES RESULTING FROM INSECT ATTACK.

The presence of pests on citrus fruit usually causes blemishes that place such fruit in a lower grade. It is generally considered that fruit which has been attacked by the rust mite is also one size, or 12½ per cent, smaller than it would otherwise be. Fruit without blemishes caused by pests probably will reach the market with less decay.

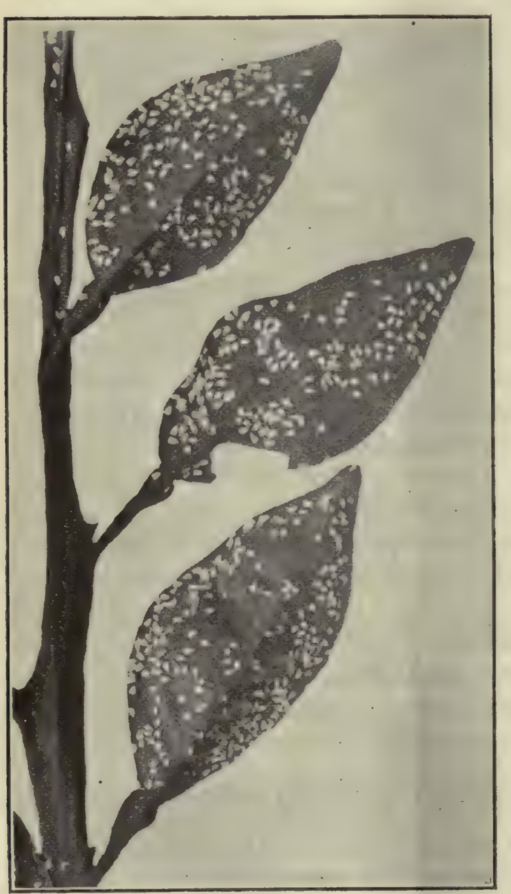

FIG. 1.—Adults of the citrus white fly crowding the under surface of new orange leaves. Adults appear slightly less than normal size. (Morrill and Back.)

The better grades of fruit are more marketable. High-grade fruit finds an early and ready market. Fruit badly attacked by insects and mites is usually sold late in the season, after sustaining large losses from dropping and incurring the liability of damage from frosts.

The work of the pests devitalizes the trees. Much of the bearing wood on the inside of the tree is killed, thus reducing the yield. It requires much additional fertilizer to produce a crop of fruit when pests are present.

METHODS OF CONTROLLING CITRUS PESTS IN FLORIDA.

Florida growers have attempted to control citrus pests by three methods: (1) Fumigation, (2) spraying, and (3) encouragement of beneficial fungi.

FUMIGATION AND SPRAYING.

Of the two artificial methods of control, spraying and fumigation, spraying is superior under Florida conditions at present. Fumigation—excellent as it is under weather conditions such as exist in California—is not promising in Florida, where the dormant season for citrus trees is too short to permit of the advantageous use on a large scale of fumigating outfits. There are also other objections to the general adoption of fumigation for the average grove in Florida. On some groves, however, fumigation[1] could be used successfully.

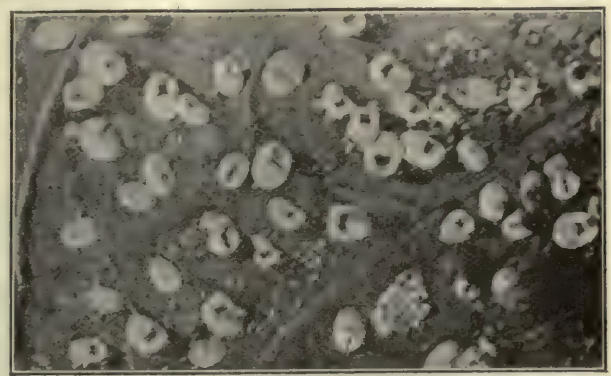

FIG. 2.—Pupæ and pupa cases of the citrus white fly. The pupa cases do not collapse after the adult emerges, like those of the cloudy-winged white fly, but remain rigid. (Morrill and Back.)

FUNGI.

There are a number of beneficial fungi that kill insects in Florida. These do an immense amount of good and should be present in every grove in the State. The most valuable of those killing citrus insects are the red-headed[2] and gray-headed[3] fungi that kill the purple scale, and the red (fig. 7),[4] yellow,[5] brown (fig. 8),[6] and white-fringe[7] fungi that kill the white flies. Under the most favorable climatic conditions these fungi keep the insects well in check. These favorable conditions usually do not obtain, and both scale insects and white flies become abundant and cause much damage, often before a grower realizes the true situation. These fungi are active about five months during the rainy season in summer, leaving many of the injurious insects to multiply unchecked

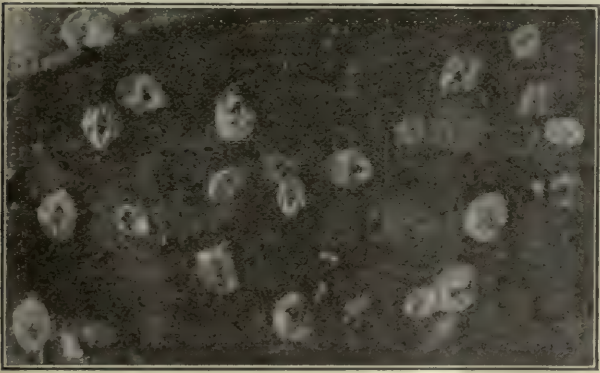

FIG. 3.—Pupa cases of the cloudy-winged white fly. They are very filmy, collapse after the adult emerges, and fall easily from the leaf. (Morrill and Back.)

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[1] Morrill, A. W. "Fumigation for the citrus white fly, as adapted to Florida conditions." U. S. Dept. Agr., Bur. Ent. Bul. 76. For sale by Superintendent of Documents, Washington, D. C., for 15 cents.

[2] *Sphaerostilbe coccophila* Tul.

[3] *Ophionectria coccicola* E. & E.

[4] *Aschersonia aleyrodis* Webber.

[5] *Aschersonia flavo-citrina* P. Henn.

[6] *Aegerita webberi* Fawcett.

[7] *Microcera* sp.

during the remainder of the year. The fungi kill the insects only after the tree has given up its vitality to furnish nourishment for the insects' development. As a rule, when fungi are depended upon as the only method to free trees from insect attack, the trees are left in a weakened condition, often with much dead bearing wood and sparse foliage, before the fungi succeed in temporarily reducing the insects to a point where little damage follows.

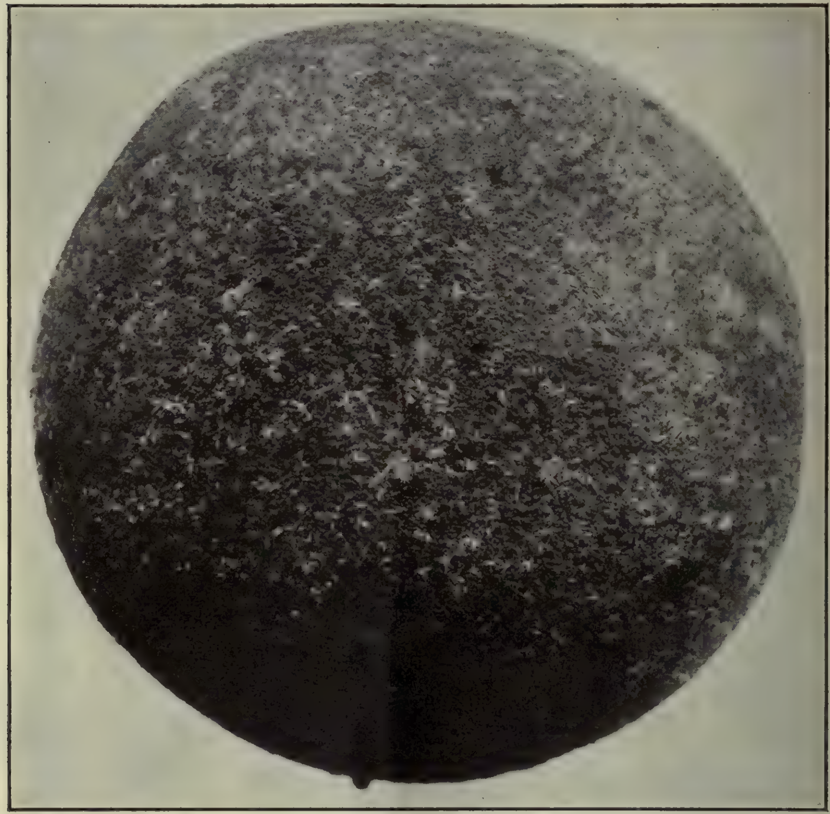


FIG. 4.—A grapefruit heavily infested with both the Florida red and the purple scales in all stages of development. Note that the scales form a scurf over the rind.

SPRAYING COMING INTO GREATER FAVOR.

Enthusiastic supporters of control by natural agencies contend that it is more profitable to grow lower grades of fruit without treatment than the better grades with treatment. Yet a system of spraying for improving grove conditions has been gradually adopted by men who, only a few years before the Bureau of Entomology began its work, depended upon fungi as the best all-round method of control. This change from dependence upon fungi to spraying with insecticides has come partly through the realization that parasitic fungi, excellent as they are, are not a complete method of insect control, but should be supplemented by spraying with insecticides. The growing use of spray mixtures and the spraying schedule advocated in this bulletin has also been an influential factor in bringing about this change. Spraying as a method of control has been followed successfully in Florida by many who are acknowledged to be successful growers.

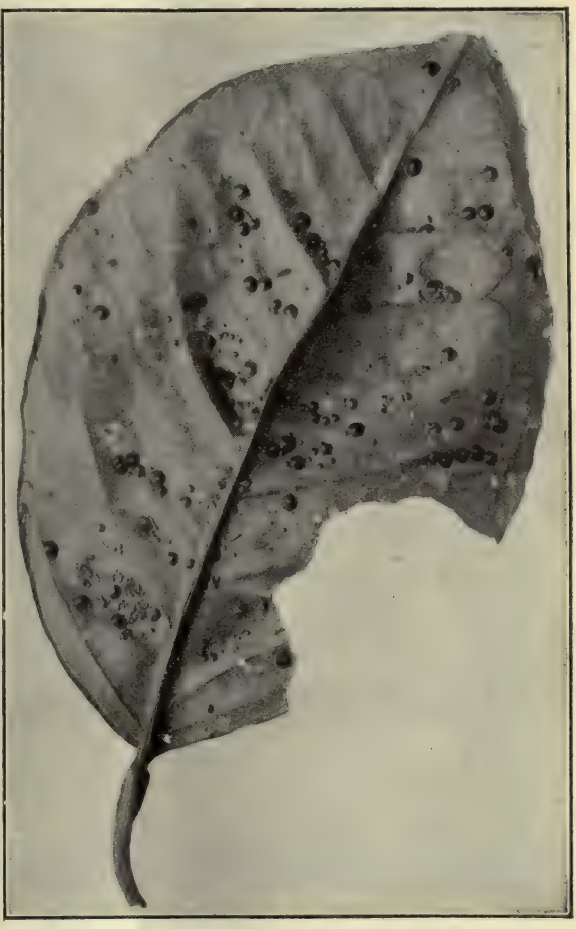


FIG. 5.—The Florida red scale, showing the adult females and young stages. The lower portion of the leaf has been eaten by a grasshopper.

REASONS FOR BAD RESULTS IN THE PAST.

Spraying, however, taken throughout the citrus area, has not yielded satisfactory results. Growers have not obtained satisfactory results from spraying and have become discouraged for two main reasons: (1) Lack of reasonable thoroughness on the part of laborers and (2) lack of a proper appreciation of the requirements for spraying on the part of the grove owner. (See fig. 9.)

Because success did not follow a single haphazard application of an ineffective insecticide, spraying has been pronounced a failure by many. The writer has examined leaves from sprayed groves and found not more than 10 per cent of the insects killed. He has known personally of instances in which grove owners have purchased reliable and expensive power sprayers only to turn over the mixing of the insecticide and the spraying of the trees to uninstructed labor. Many fine groves have been sprayed by men who did not hit 40 per cent of the insects with the spray. One crew operating a power outfit did not hit the lower surface of more than 1 leaf in 1,000. Spraying can not succeed under such conditions.

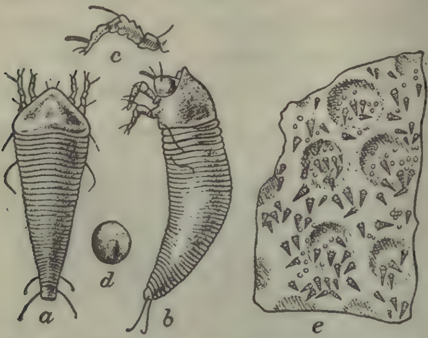


FIG. 6.—The rust or silver mite: *a* and *b*, Dorsal and lateral views of adult mite; *c*, leg of same; *d*, egg; *e*, lemon rind showing pits normal to surface and mites and eggs. All greatly enlarged. (*a* to *d*, Copied from Hubbard; *e*, Marlatt.)

EQUIPMENT FOR SPRAYING.

Much dissatisfaction in spraying for the control of pests on citrus trees arises from the use of inefficient equipment. The equipment for spraying should be adapted to the particular needs of the grower and also to the size of the trees and the nature of the grove to be sprayed.

PUMPS.

Barrel pump.—A barrel pump (fig. 10), which will supply one lead of hose, will serve every purpose if the trees are low and only a small amount of spraying is required, and will save investment in a large machine until such time as the work necessitates one. For three years or longer after planting this pump will answer the purpose very satisfactorily. In fact, one of the most successful grove owners, who sprays, has used a barrel pump for three years in his grove of 800 trees about 10 feet in height. A barrel pump, indeed, is a necessity in any grove where insects are controlled by spraying. Many times it is necessary to spray one tree only, and this can be done easily with a barrel pump, thus eliminating the necessity of using a large machine. A barrel pump is also suitable for spraying

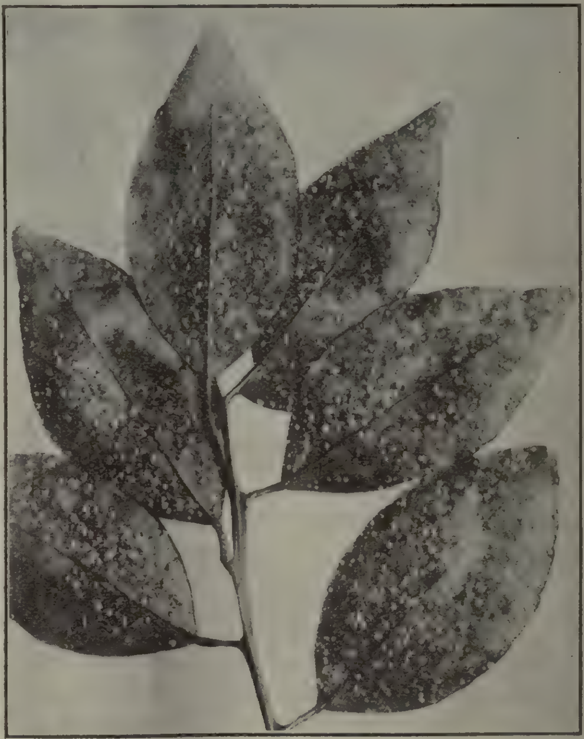


FIG. 7.—Red fungus attacking the citrus white fly. (Morrill and Back.)

in groves where palmetto and other trees have not been removed, and in groves so thickly planted that it is difficult to use a power sprayer. A barrel pump can be used also for making emulsions and for whitewashing.

For extensive operations, however, experience indicates that either a large lever pump or a gasoline power outfit should be used.

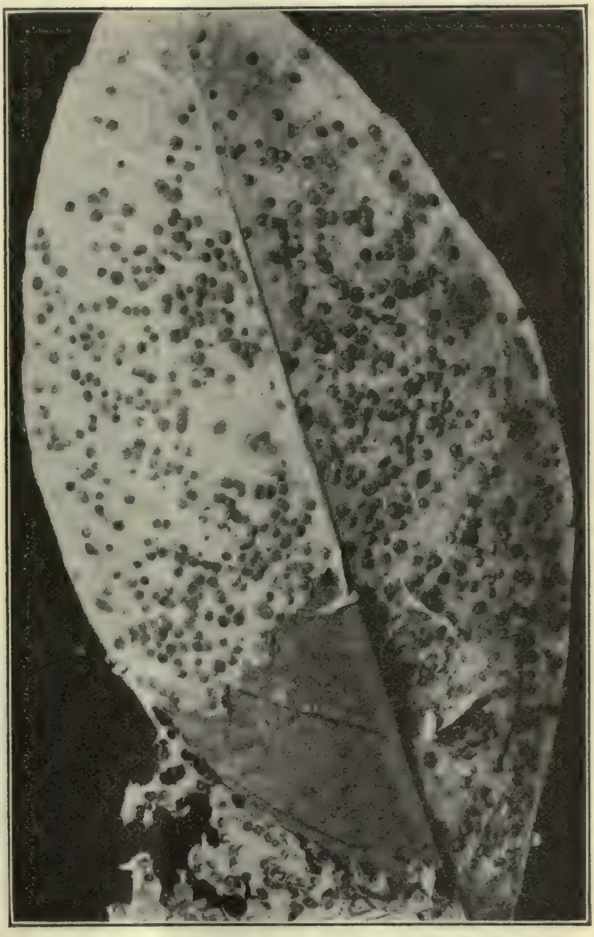


FIG. 8.—The brown fungus attacking the citrus white fly. The mycelium of the fungus has been turned back from the lower left portion of the leaf. (Morrill and Back.)

Lever pump.—The large double-acting hand pump (fig. 11) can be used for spraying even the largest trees and may be recommended for groves as large as 10 acres. This type of pump, like the barrel pump, seldom needs repairs and will supply two nozzles very satisfactorily. These pumps can be purchased in connection with a tank or separately. If purchased separately, a barrel is used to hold the spray material. The chief difficulty with both the barrel pump and the lever pump is the fact that it costs at least the wages of one man to furnish the power. This usually amounts to about 6 to 10 times as much as the cost for gasoline to run a power outfit. Another disadvantage in using any type of hand-power pump is the irregularity of the pressure and the lack of stimulus to the men that is furnished by a power-driven machine.

Gasoline power outfit.—For any extended work in spraying a power outfit (figs. 12, 13) should be used. Owing to the nature of the soil in Florida, spraying machines should be made as light in weight as possible. It is very doubtful if any machine is practical under the average grove conditions in Florida that weighs more than 1,800 pounds. To be of the greatest value a machine should weigh not more than 1,400 to 1,600 pounds. It is also desirable in many instances to have a cross reach for the truck which will permit it to be turned in a very small circle. The tires should be 6 inches in width and the diameter of the wheels should be as great as is practicable. In many instances, however, where the branches of the trees are near the ground, it is desirable to have the machine as low as possible to prevent pulling off fruit and the leaves. Some machines are built unnecessarily high and when used in such a grove cause much damage.

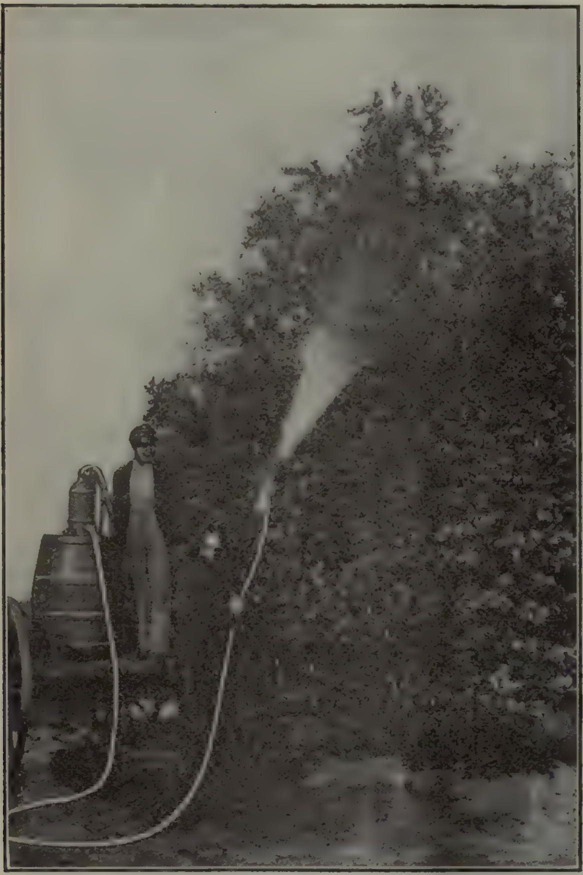


FIG. 9.—It is impossible to get good results without extension rods and this type of spraying is useless. The grower failing to get results condemns all spraying as useless when the fault lies in the lack of the proper equipment.

Since the wheels with which the spraying machines are fitted are extremely heavy, often comprising half of the weight of the empty machine, it is extremely desirable that lighter wheels be constructed for this special purpose. A machine for Florida conditions should be fitted with a tank located in front of the engine and pump (*not* as in fig. 14). This gives the operator an opportunity to attend the engine from the rear of the outfit without interfering with the team, and also eliminates the danger which usually follows when an engine is placed immediately in the rear of a pair of mules. The tank should contain an opening large enough to permit a man to go inside to clean it out. The opening should be fitted with a removable fine-mesh wire strainer. The tank and the cab over the engine and pump should be flush with each other (see fig. 13), in order to prevent the catching of branches, carrying off of fruit, and other injury to the trees.

The engine should be not less than 1½ horsepower. It is the consensus of opinion that a light engine of 2½ or 3½ horsepower is preferable to one of less power. The engine by all means should be fitted with a good governor. The pump should be fitted with a regulator which is accurate, and will take care of the capacity of the pump whether the nozzles are turned on or off. The pressure should not vary if the nozzles are cut off. Both the engine and the pump should be protected from sand by means of canvas curtains on the sides and rear. The wheels raise considerable sand to the height of the engine and pump and the wind may then blow it into the machinery. The writer has known of instances in which machinery unprotected from the sand has been ruined in a single week.

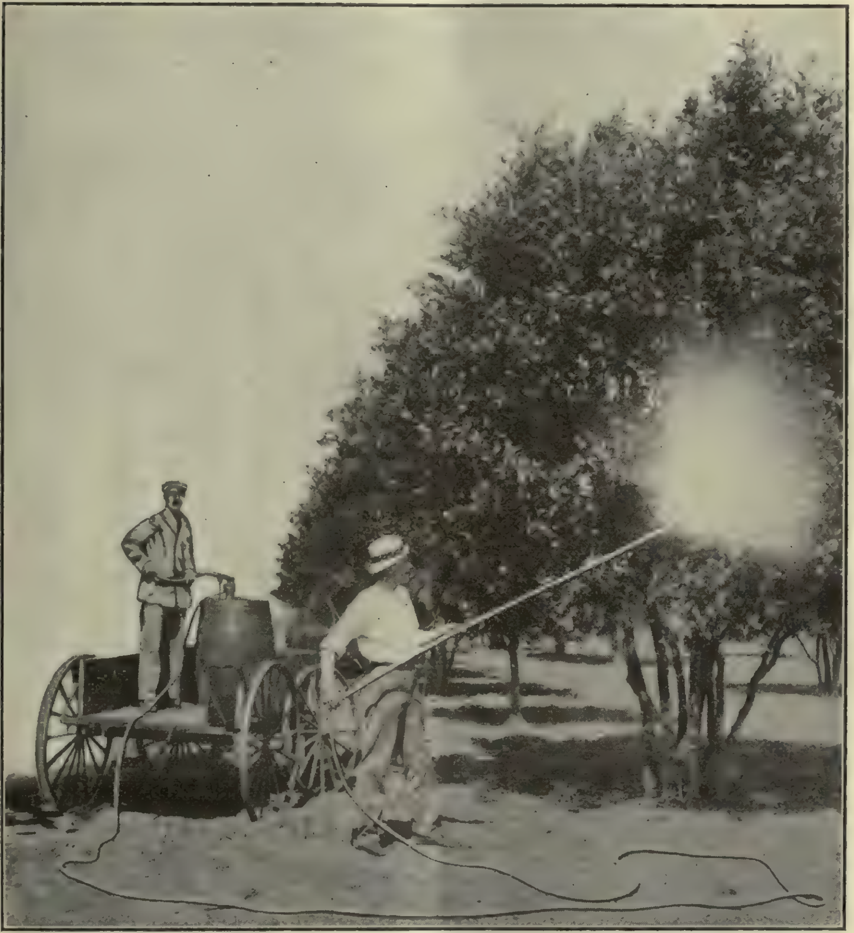
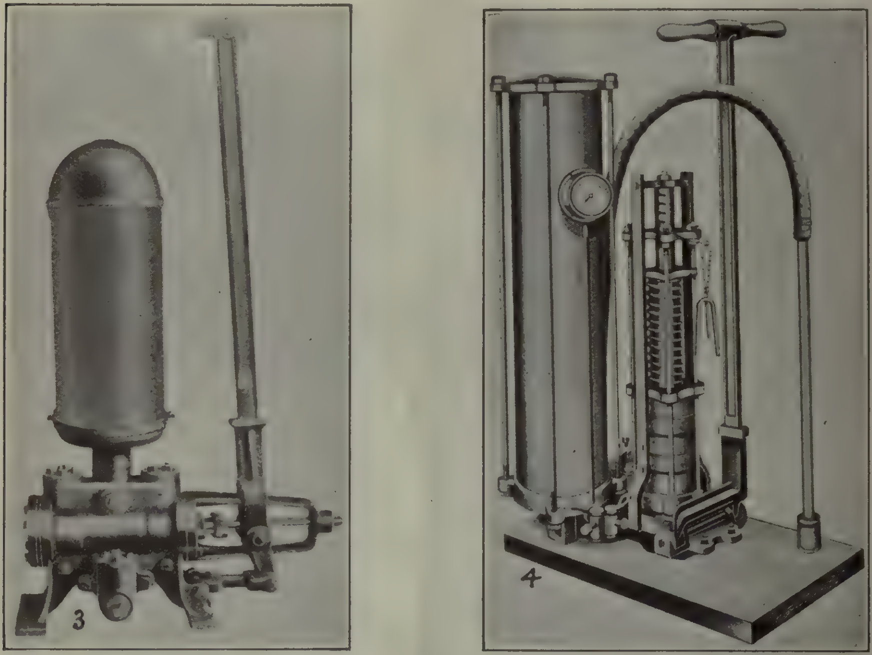


FIG. 10.—A barrel pump is satisfactory for small operations. The spray is directed upwards to hit the white fly infesting the lower surfaces of the leaves.

Unsatisfactory types of apparatus.—A pump run by means of gearing attached to the wheels (fig. 15) is not suitable for spraying citrus trees. It often requires as much as 15 gallons to spray a tree, and to apply this amount it would be necessary to spray a part of the tree and then drive the machine a considerable distance to get enough pressure in the air tank to continue spraying. This involves too great a waste of time and labor. No citrus grower should purchase such a machine for spraying citrus trees. It is also useless to attempt any spraying other than a few small trees with a bucket, small compressed air, or knapsack pump.



1 2

FIG. 11.—These hand-power tank outfits are satisfactory for many groves in Florida. They are durable and do not easily get out of repair. They will supply two leads of hose, and may also be used in making emulsions. (Quaintance.)

HOSE.

The same kind of hose should be used for the barrel pump, the larger lever pump, and the power outfit. This hose should be not less than 7-ply if it is known as "wrapped." There is also a hose which is known as "double continuous net weave," which has given satisfactory results. This type is much lighter, and is therefore much easier to handle in a grove than the heavier type. So far, however, there are no indications as to whether the wrapped or the woven hose is superior. It is useless to attempt to spray with ordi-

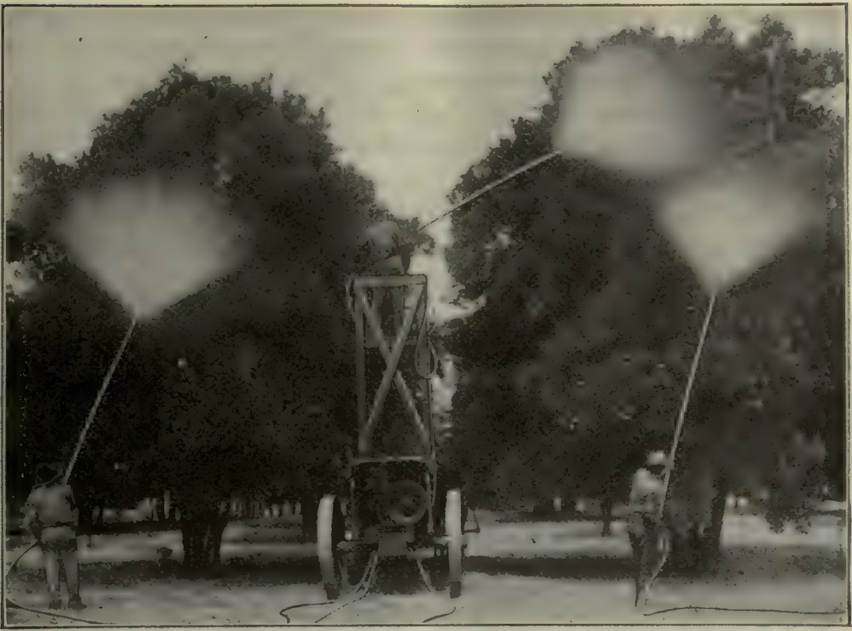


FIG. 12.—A power spraying outfit of the approved type with the engine in the rear where it can be attended without loss of time. Note the tower which enables the sprayer to reach the topmost branches of the trees.

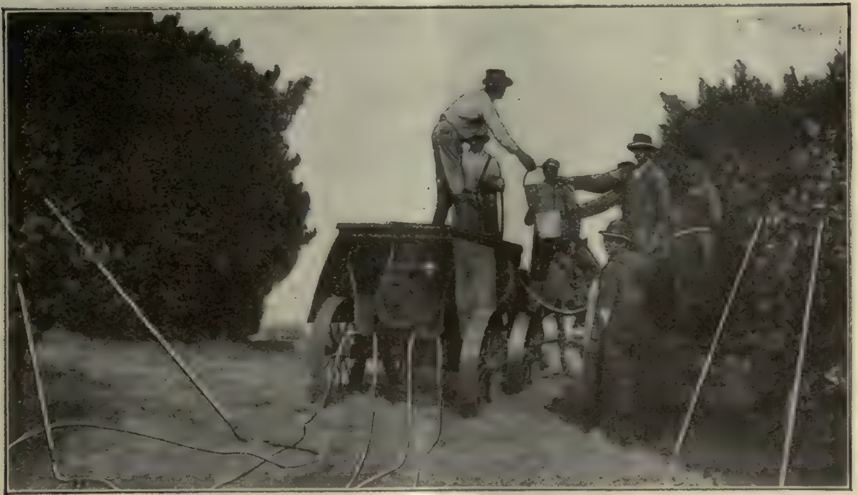


FIG. 13.—Water supply wagon to the right of the spraying machine. Such a wagon, used to haul water to the machine in the grove, nearly doubles the number of the trees that can be sprayed without much additional cost. Note that the cover over the engine is flush with the spray tank.

nary garden hose, even when using a barrel pump. The writer has broken garden hose in the space of one hour. Hose should be smooth on the outside instead of corrugated, since smooth hose can be repaired by wrapping with adhesive tape. Experience indicates that it is much better to have hose of one-half inch diameter than a smaller or a larger size.

For convenience in operation the leads of hose should be from 40 to 50 feet long. Hose of this length permits the operator to reach the farthest side of the largest trees in groves where they are planted at the average distance. Since the hose wears out first at the point of attachment to the machine or rod, this length permits the hose to be cut off and reattached without making it too short. With a long hose both the mules and the machine may be kept out of range of the spray.

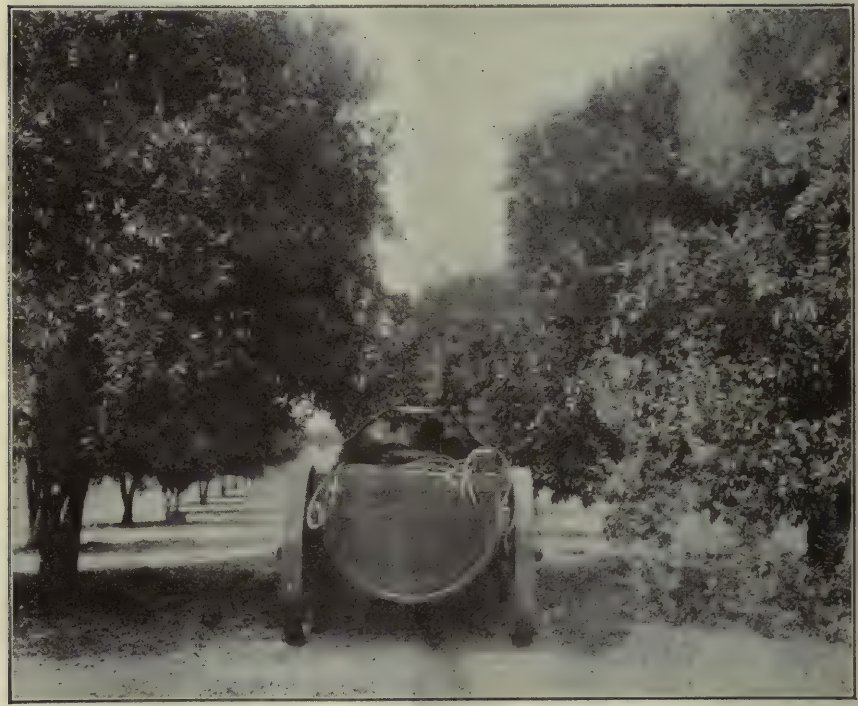


FIG. 14.—A power spraying machine of the underslung type, with the engine and pump forward, the tank in the rear.

RODS.

In spraying, an extension rod ranging from 8 to 12 feet in length should be supplied with each line of hose. The length will depend upon the height of the trees. This rod may be a regular bamboo rod or a small gas pipe. The former is more suitable for this work because it is lighter and more easily handled after becoming wet, and is not easily bent, hence the operator always knows just how to turn the rod to direct the spray upward. The bamboo rods, however, will not stand such rough usage as those made of gas pipe, and for this reason many growers have stopped using these light rods. An old piece of rubber hose may be slipped over the end which is attached to the hose, so that the operator may handle the rod with greater facility. Rods of gas piping should be kept straight and they should never exceed 10 feet in length. Owing to the more thorough work that can be done with the light bamboo rods, and the greater ease with which they may be handled, they should be used whenever practicable. With care they often last for years.

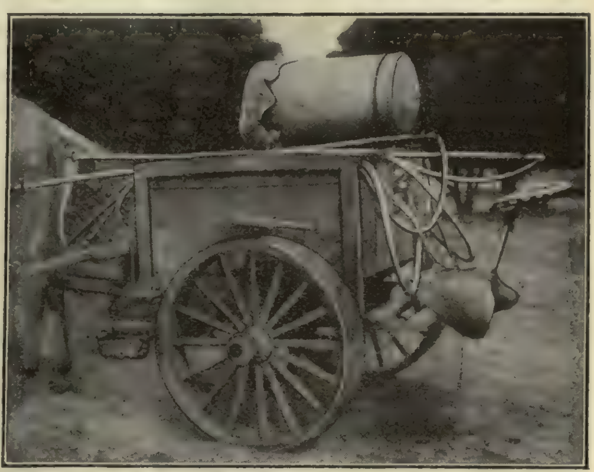


FIG. 15.—The geared spraying machine above is not suitable for spraying Florida citrus trees.

CUT-OFFS.

There should be a cut-off between each line of hose and the machine, so that if only one line of hose is required, or if an accident temporarily incapacitates one lead, the other lead or leads can be used. There should be an additional cut-off between each extension rod and the hose, so that the operator can prevent any undue waste of spray material, either in going from row to row or from tree to tree. A cut-off placed in this position will enable the operator to clean out any impediment in the nozzle without going back to the machine to cut off the liquid. A cut-off should always be kept in good repair, for if it does not cut off the spray *completely*, it is useless, and should be discarded or repaired immediately.

NOZZLES.

In spraying citrus trees the object is to obtain as wide a field as practicable so that the greatest amount of leaf surface can be sprayed in the shortest time. Penetration is not so important in spraying for the pests on citrus. An angle nozzle, from which the spray emerges in the form of a cone, at an angle of from 45° to 60°, is the best to obtain this result. It is also much better if two of these nozzles are placed on a Y so that the cones of spray intersect at from 8 inches to 12 inches from the nozzle. When so arranged the hollows of the cones are broken and it is much easier to attain a perfect wetting of all the foliage. The object in spraying a citrus tree should be the complete wetting of both the upper and lower surfaces of the leaves in the shortest possible time. The writer has found after many years' experience that much time is wasted in using nozzles of small capacity. It requires at least twice as long to spray a tree using a nozzle with a very tiny hole in the disk as it does using one of proper capacity. It is advisable to use a disk with an opening not less than one-twentieth of an inch in diameter and not greater perhaps than one-sixteenth of an inch.

SPRAYING ACCESSORIES.

Every outfit, whether it be a barrel pump, a large lever pump, or a power outfit, should be fitted with a wrench, pliers, hammer, and such other tools as are necessary. It will also save much trouble and annoyance if the materials which are placed in the tank are first strained through *double thicknesses of cheesecloth.* This will cost only a few cents and, according to the experience of the writer, may save several dollars a day in time. In case a small leak appears in the hose it can be dried carefully with a cloth and repaired with adhesive or "tire" tape; this has been known to double the durability of a hose. Copper wire or other wire should be available in order to repair hose connections in case they should separate. Patent hose clamps are now to be had, and if used these will eliminate much of the trouble usually arising from the separation of connections. Each outfit should be provided with proper measures and buckets to enable the operator accurately to calculate the amount of the insecticide used, besides buckets for filling the tank.

INSECTICIDES.

The pests of citrus trees considered in this bulletin may be divided into two groups with relation to the insecticides involved. (1) Those controlled by the soap-and-oil sprays, such as the white flies and scale insects; and (2) those controlled by the sulphur sprays, such as the rust mites and red spiders.

INSECTICIDES FOR WHITE FLIES AND SCALE INSECTS.

Experiments covering a 10-year period have shown that the best insecticides for controlling white flies and scale insects are those having a base of cheap lubricating oil or what may be called "paraffin oil." These oils are made into emulsions according to the formulas following.

Fish-oil soap at the rate of from 5 to 8 pounds to 50 gallons of water in May, or from 12 to 16 pounds to 50 gallons of water during the winter season, is an effective spray that has been used for many years without injury to the foliage or fruit.

While both the fish-oil soap and the oil emulsions are effective in killing the white flies and scale insects, experience indicates that the latter are far superior to the former under Florida conditions. This superiority is due to the physical properties of the oils. The high boiling point and great viscosity possessed by these oils make them operative over a longer period of time after application, and, too, they are only slowly affected by average temperatures and showers. Foliage sprayed with miscible oils remains slightly oily in appearance and to the touch for several weeks after spraying. Fish-oil soap leaves no such evidence that the trees have been sprayed. The oil spray is much less affected by showers than is the fish-oil-soap spray. Summer showers falling after the oil spray has once had an opportunity to dry on the foliage have little effect in lessening the efficiency of the spray. Such showers, however, have a very evident effect upon the number of insects killed by the soap spray. The effectiveness of the weaker strengths of fish-oil soap is much more reduced by showers than is the effectiveness of the weaker strengths of oil sprays.

In experimental work on a large scale for the control of the citrus white fly the miscible-oil sprays have given better results than have the soap sprays. This greater efficiency seems to be due, not to a higher percentage of larvæ and pupæ killed when the spray is applied, but to the effect that oil sprays exert upon unhatched eggs or upon the young larvæ hatching from them within 10 to 14 days after spraying. The oil forms a film over the eggs which prevents a large percentage from hatching, and the young larvæ from those which do hatch are killed either in the act of emerging from the shell or in crawling over the oil-coated leaf. Those who are in touch with the white-fly problem appreciate the fact that no matter how efficacious an insecticide may be, in killing larvæ and pupæ on the leaves at the time the spray is applied, if it does not either kill these unhatched eggs or remain operative long enough to kill the larvæ that subsequently hatch, much of the benefit of spraying is counterbalanced by reinfestation.

There are two ways of making miscible-oil emulsions: (1) Without heat; (2) with heat. The first is called the "cold-stirred emulsion"; the second, the "boiled" emulsion. Both kinds of emulsion are efficient, reliable, and easily made.

COLD-STIRRED EMULSION.

Formula.

Fish-oil soap:		
By weight	pounds	8
By measure	gallon	1
Paraffin oil, 24° or 28° Baumé	gallons	2
Water	gallon	1

Directions for preparation.—In preparing the stock mixture, the soap should be put into a receptacle of about five gallons' capacity and the oil added while the mixture is being vigorously stirred. It is important that the oil be added in small quantities at first, and that the stirring be sufficient to keep the oil and soap in the form of an emulsion after each addition of oil. Thus, at first about a pint of oil should be added to the soap and the mixture stirred until no free oil appears. As the amount of oil is increased it should always be stirred or mixed thoroughly before the next addition is made. After the required amount of oil has been added and after free oil has ceased to appear on top of the soap, the water is slowly poured in, about 1 quart at a time. As previously stated, the only apparatus required to make this formula in a small way is an ordinary galvanized iron pail and a paddle.

The foregoing formula may be modified under certain conditions, as the quantity of soap will depend largely upon the time consumed in adding the oil and the amount of stirring; the amount of soap being lessened if the stirring be uniform and ample time be taken in the careful preparation.

If it be desired to make this formula on a large scale, a 300-gallon cylindrical tank may be fitted with paddles, which are attached to a shaft in a vertical position, occupying the center of the tank. The shaft is fitted with a beveled gear on the upper end. A horizontal shaft is then connected with the vertical shaft by means of another beveled gear, while the other end has a pulley to connect with the engine. A series of brakes should be fitted to the sides of the tank to prevent the entire mass from turning around with the paddles. An entire barrel of fish-oil soap may be placed in this tank and the stirring begun at once. Two barrels of oil may then be run into the soap through an inch or 1½-inch hole in the end of the barrel, or the oil may be run out of the bung-hole. After the oil has been added, either one-half or two-thirds of one barrel of water can be added to complete the preparation of the stock solution. In the final spray this should be so diluted as to contain about 1 per cent of oil by adding 1 gallon of the stock solution to 50 gallons of water.

It is also highly practicable to fit up a 50-gallon barrel in the same way as described above for the 300-gallon tank. By attaching a crank to the horizontal shaft the mixer can be run by hand instead of by an engine. Such a mixer, designed and used by Mr. J. A. Stevens, De Land, Fla., has been found practicable. The writer has used an ice-cream freezer for making an emulsion, by removing the can and adding a false bottom of 1-inch board to hold up the stirring gears. In fact, many different types of mixers can be constructed, depending on the material available and the scope of the work involved.

BOILED EMULSION.

Formula.

Paraffin oil	gallons	2
Water	do	1
Fish-oil soap	pounds	2
or		
Hard soap	do	1

Directions.—Put oil, water, and soap into a kettle or other vessel that will stand fire, and heat to the boiling point. While still very hot, pump the material (see fig. 16) into another vessel and then back again. Emulsion can not be made by this formula without a pump; stirring is not sufficient.

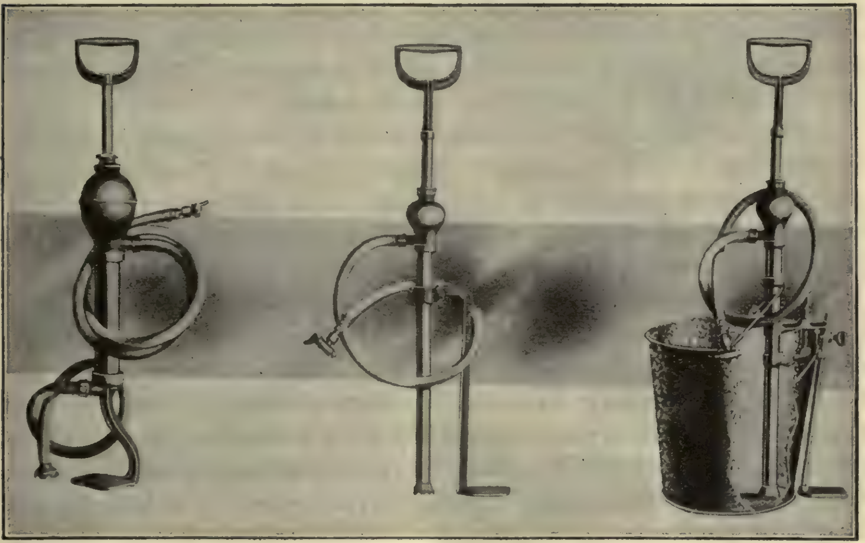


FIG. 16.—A pump used for emulsifying the oil. This is used in making the emulsions on a small scale. (Quaintance.)

Dilute to make 200 gallons of spray material.

For making the above formula the writer has used 9 and 15 gallon kettles, wash boilers, and 100-gallon oil tanks with uniform success.

If it is desirable to make this formula on a somewhat larger scale, the materials can be heated in a large kettle or other vessel and then dipped into a barrel pump outfit and the mixture emulsified by pumping it back upon itself. For safety it is best to have all the material pass through the pump twice, but it must not be pumped after it has become cool. Excessive pumping will break up a good emulsion. It can also be heated in a large galvanized oil tank having a capacity of 4 barrels and emulsified by means of the spraying machine. In this case the suction hose should be put into the tank of hot material and the discharge hose into the spray tank. For the second pumping, put the suction hose into the spray tank and the discharge hose into the storage barrels. When the spraying machine is used for this purpose, an old suction hose should be used, as well as a discarded piece of hose for the discharge end. This should be not more than 10 feet in length. The material should be run through an ordinary nozzle with the disk left off. The overflow will not emulsify this material.

At present this "boiled formula" is made by the Florence Villa Citrus Growers' Association and also the Tavares Association. These two plants are fitted with two 300-gallon tanks and the material is heated by steam. One association uses a large pressure pump with a 2-inch intake and a discharge of three-fourths inch. The material is pumped from one tank into another and then pumped over or back upon itself for about 10 minutes, and then it is barreled. This plant can make 3 barrels of emulsion in about 20 minutes. The other plant uses a water injector pump operated by steam.

Owing to the high temperature of the mixture, pumps used for emulsifying should have metal valves. If made of other material their period of usefulness is very short. It should always be remembered that a pressure pump must be used for emulsifying. The writer has never succeeded in making an emulsion with a rotary pump.

Difficulties that may arise in making the boiled formula are: (1) A lack of sufficient heat, (2) improper pumping, or (3) an improper emulsifier. In many tests the water and soap only were heated, and failure to produce a perfect emulsion resulted in every instance. On the other hand, when all the materials were heated together a perfect emulsion was secured. The materials should be heated until a slight foam or a few bubbles appear, but it is not necessary to boil for any length of time.

Some growers have failed because they attempted to stir the materials together with a stick, and others because they used a rotary pump. Neither of these is satisfactory.

The emulsifying agent is very important. There is no doubt that potash-fishoil soap is the most satisfactory of all soaps for the making of any of these emulsions. When this material is used the oil very seldom separates and the resulting emulsions never become too thick to be poured or handled conveniently. On the other hand, when hard soaps are used which are made from caustic soda and fats containing large proportions of stearin and small quantities of rosin, the emulsions separate on cooling, and will cause much trouble in mixing on the day after they are made. If the emulsion made from any hard soap found on the market is used on the same day that it is made no trouble will be experienced. The "cold-stirred" formula is difficult to make with hard soaps. The writer has found it impossible to make emulsions by using any of the soap powders, even if flour is used as a stabilizer.

Before any spray material is applied to a tree it should be tested to determine if it is a perfect emulsion. To do this, add a small amount to some soft water; if no oil floats or no thick, greasy scum forms, it is satisfactory. If free oil appears the emulsion is imperfect and should not be used. Great care should be used to stir the contents of the barrel thoroughly before any test is made.

The present price of potash-fishoil soap makes the "cold-stirred" formula somewhat expensive, but when the market becomes normal its cost will be reasonable. It has an advantage in that it will keep indefinitely and will not separate under ordinary conditions of temperature or usage. It has an added advantage in that no apparatus, other than an ordinary pail and paddle, is required for making it on a small scale.

Just at present the boiled-emulsion formula is the one which will appeal to the average citrus grower in Florida. It is, beyond all question, the cheapest effective insecticide for white flies and scale insects.

The oils used in the making of these formulas usually test from 24° to 32° Baumé and have a viscosity not less than 200. The best oils for spraying purposes have a viscosity of about 300 to 400 and they may be purchased from any of the oil companies operating in the citrus-growing belt. Petroleum fuel oil and distillate or gas oil may also be used and when applied should be used at twice the strength indicated for the lubricating oils. The soaps may be purchased from any grocery or fertilizer company.

PROPRIETARY MISCIBLE OILS.

There are several proprietary miscible oils on the market which the writer has found to give highly satisfactory results. These should be diluted so that the spray material will contain somewhere between ¾ per cent and 1 per cent of oil. The writer would advise the use of oil emulsions when diluted to about 1 per cent. Experience indicates that such substances as rosin oil and sulphuric acid should not be used in proprietary insecticides.

SPRAYS FOR RED SPIDERS AND RUST MITES.

It has been known for many years that sulphur sprays are successful against both rust mites and red spiders. Lime-sulphur solution is no doubt the best form of sulphur which has ever been devised for the control of these pests. The main value of this solution over other forms consists in its permanency, since after it once dries on the leaves it remains for a considerable length of time, whereas other forms are easily washed off by rain or dissipated by dew. Directions for making lime-sulphur solution are given in other publications of the department.[1] For these pests it is best to use lime-sulphur not weaker than 1 gallon to 75 of water. The maximum strength to be used will depend entirely upon the season of the year and what other objects the grower may have in view by spraying. This material *can not be used in combination with the oil sprays*, but it may be used in combination with the tobacco sprays for thrips in the bloom.

SODA-SULPHUR SOLUTION.

The main value of the soda-sulphur solution consists in the properties which enable it to be used in combination with the oil emulsions. Owing to the superiority of lime-sulphur solution the use of soda-sulphur solution alone is not advised. It has a distinct place, however, in forming a good combination spray for white flies, scale insects, and mites. It is made as follows:

Formula.

Flowers of sulphur	pounds	30
Caustic soda (98 per cent)	do	20
Water	gallons	20

To remove the lumps from the sulphur place a wire screen over the barrel and rub the sulphur through with the hands, then slowly add about 3 gallons of water and stir so as to form a thin paste. The caustic soda should then be added and the entire mixture stirred vigorously. Some growers add the caustic soda gradually to prevent too vigorous boiling, and others add it all at once with water enough to prevent too vigorous boiling. It is also practicable to dissolve the caustic soda in about 4 gallons of water before it is added to the sulphur. The boiling will be quite violent and it may be necessary to add a gallon or more of water during the process, but whether or not this is necessary can be determined by the operator.

The main difficulty in making this formula is that too great heat is generated, which liquefies the sulphur before it can be acted on by the caustic. If sediment forms this has been the cause. To prevent this excessive heat add more water in the beginning and during the process. After boiling has ceased add about 16 gallons of water.

For spraying against red spiders and rust mites use 1 gallon of this stock solution to 40 gallons of water. *When used with the oil sprays* the strength should be a little weaker than if used alone. When so used dilute 1 gallon to 50 gallons of water. If it is to be used in combination with oil emulsion it should be added to the tank or barrel of water before the oil emulsion.

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[1] Farmers' Bulletin 908, "Information for Fruit Growers about Insecticides, Spraying Machinery, and Important Insect Pests," by A. L. Quaintance and E. H. Siegler.

SOFTENING HARD WATER.

Whenever practicable the growers should use lake[1] water for spraying with the oil emulsions. When a proper emulsion is so used, no trouble will be experienced. If only deep well water or sulphur water is to be had for spraying purposes, some means must be taken to eliminate those chemicals which combine with the caustic soda in the oil emulsions to set the oil free. If such water is used without treatment, free oil sometimes appears on the surface, but usually a thick, greasy mass forms. Usually when sprayed on a tree the twigs are killed to a considerable extent. Some of these well waters are so hard that it requires an enormous amount of soap to soften them. Our experience indicates that caustic soda when used alone will not give satisfactory results. It has been found that if 1 pound of caustic soda per 100 gallons is used in addition to from 3 to 6 pounds of soap the oil emulsion will mix satisfactorily. Caustic soda should be dissolved in 2 or 3 gallons of water and then added to the full tank and the entire mixture stirred and left to stand about a minute. Before adding, the soap should have been dissolved at the rate of about 1 or 2 pounds per gallon of water. After the soda and soap solution have stood for 2 or 3 minutes the insecticide may be poured in.

It is advisable for the grower to proceed on a small scale at first, using a barrel of water or less. After the first addition of caustic soda and soap some insecticide should be added. If the thick, greasy scum forms within the period of 5 minutes, another test should be made, using a larger quantity of both caustic soda and soap.

FACTORS IN OBTAINING SUCCESSFUL RESULTS.

In order to obtain satisfactory results from spraying, the grower should carefully plan the operations a considerable time in advance.

PRELIMINARY CAMPAIGN.

If it is the intention to purchase a spraying outfit, one should be ordered at least two months before it is needed. If a spraying outfit is already at hand, great care should be taken to overhaul it most thoroughly at least a month before spraying begins. This will afford plenty of time to send for parts, if any need to be replaced. The tank should be cleaned out carefully, and soaked so that it will not leak. The pump should be carefully repaired, and if any parts are worn out or broken they should be replaced. It is essential that the valves be in perfect condition and these should be carefully polished with emery dust or emery cloth. The valve seats if worn should be changed, or new ones substituted. It may be that these can be reamed out by a machinist. In case any gears are badly worn, new ones should be obtained. The engine should, likewise, be carefully gone over to see that it is ready for operation. If the cut-offs leak they should be replaced or ground, and the nozzles and rods should be carefully examined. In regard to the hose, it is always advisable to have an extra lead, so that in case those in use leak badly the spraying can proceed without delays.

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[1] It may be explained that owing to limestone formation in Florida, well water is usually "hard."

The insecticide or insecticide material for the entire grove should be on hand at least a week or 10 days before operations are to be begun. It is advisable that the quantity be carefully estimated, and it is better to overestimate a little than to underestimate the quantity, as in the latter case the spraying operations would have to cease until another supply could be obtained.

The source of water supply is also very important. For the oil emulsions it is much better to use lake water, but if this is impossible the water from the deep wells can be used and treated as heretofore suggested. If sulphur sprays are to be used alone they will mix satisfactorily with both lake and deep well water. Wherever practicable the water should be hauled to the machine by a supply team (fig. 13). Where two leads of hose only are being used, this hauling can be done with one horse and a boy with two barrels, unless, of course, the water supply is at a very great distance away. When four leads of hose are being used, it will be necessary to use a double team and four barrels or a supply tank. If the water for spraying is hauled to the machine, instead of going to the water supply with the machine, the number of trees sprayed can be practically doubled. In our operations we have sprayed as many as 18 loads of 200 gallons each in 10 hours. When the water is hauled to the machine the tank filler or suction pipe may be inserted into one barrel while the spray men, with buckets, dip the other three barrels into the tank. This saves much time in filling.

Before any insecticide is used its strength should be known in order to permit the dilution of the spray to the proper strength. In case of the oil emulsions these should be diluted according to the percentage of oil they contain. The sulphur solutions should be diluted according to the quantity of sulphur in each gallon of liquid, which is usually told by the degree of density as determined by the hydrometer.

It is also of considerable convenience to be able to open a barrel in the proper manner without breaking in the head. To do this take an ax or other implement and pound first on one side of the bung and then on the other. After a few such strokes the bung will be loosened so that it can be very easily removed or "jumped" out. After this is done a paddle should be inserted through the bunghole to stir the insecticide. The insecticide should always be stirred before any is taken out for spraying. It is convenient also to nail a small piece of tin on one side of the bunghole which will act as a spout and cause the insecticide to run into the measuring bucket instead of down the side of the barrel. A hole also can be bored in the head about 1 inch from the edge on that side of the barrel which is opposite the bunghole. A faucet or molasses gate should then be inserted in the hole, and the barrel placed on its side with the faucet next the ground. The bung should then be removed to permit stirring and entrance of air. A stick can be used for this purpose. The best way to mix an insecticide is to draw off several buckets full through the faucet and pour back through a funnel in the bunghole.

SPRAYING PROCEDURE.

HOW TO APPLY THE SPRAY.

In spraying for the control of white flies and scale insects the method of application is the same whether a barrel pump or a power outfit be used. The object should be the complete wetting of both the upper and lower surfaces of the leaves as well as all the limbs and the trunk.

In applying the spray the operator should begin on the far side of the tree and work around to the point nearest the machine. The second half of the tree should be handled in like manner. If two operators are at work on the same tree they should both begin at the point farthest from the machine and proceed until they meet.

The spray should be applied to the tree in a systematic way. The operator should begin at the base and work to the top, inserting the rod among the branches so as to spray the center of the tree. The entire tree may be thus sprayed in sections, the operators proceeding alternately from the bottom to the top and from the top to the bottom. To prevent kinks in the hose, the operator in moving from tree to tree should never make a complete turn. In case kinks appear they should be immediately taken out by turning the spray rod and not by pulling the hose. In pulling kinks out of hose the hose fabric is destroyed. Such an avoidable waste of property should not be permitted.

PRESSURE.

The pressure that should be maintained depends to a considerable extent upon the agility of the man using the rod. If a man moves rapidly, a greater pressure can be maintained without accompanying loss of material than when a man moves slowly. A slow man will not be able to handle a much greater pressure than 150 pounds, whereas an active one will handle 250 pounds. It is very doubtful if a slow-moving man should be employed to use a spray rod. The pressure also depends upon the size of the hole in the disks. The smaller the hole, the greater must be the pressure to furnish sufficient spray material to wet the foliage without losing time. If a barrel pump is used, from 80 to 100 pounds will be all that can be held with one man pumping. From 100 to 125 pounds will be all that can be maintained when the large lever pump is used with one man pumping. For average conditions the power outfit should maintain from 175 to 250 pounds. When the pressure is less than 175 pounds operations should cease.

QUANTITY OF LIQUID REQUIRED TO WET TREES.

Successful results can not be obtained unless sufficient material is used to wet the foliage completely. To a certain degree the quantity of liquid used is a good criterion of the efficiency of the spraying done. We have known intelligent grove owners to use a gallon of material for a tree 10 feet high. No satisfactory results can be expected from such spraying. The quantity to be used will depend upon the density of the foliage as well as upon the size of the trees. Small trees having dense foliage require much more material than do larger trees with more sparse foliage and straggling branches. For trees one or two years old one-half to three-fourths of a gallon is sufficient. Trees 3 to 4 years old should require from 1 to 1½ gallons, and trees just beginning to bear should seldom receive less than 2 gallons per tree. Trees of large spread and 10 feet in height sometimes require as much as 10 gallons, while the very largest trees require as much as 15 gallons. The average tree of 10 to 12 feet requires about 8 gallons.

RAINS AND DEWS.

Spraying should never be done during a rain or when the foliage is dripping wet. Spraying under such conditions dilutes the spray to such an extent that it is entirely ineffective in killing the pests. Operations should cease at least 10 minutes before a shower is about to fall, in order to give the spray a chance to dry. After a shower operations should be resumed in 20 to 30 minutes, or after a large part of the drip has ceased. If heavy showers fall late in the afternoon it is improbable that spraying resumed the same day will be effective. It is seldom that the dew is so heavy as to prevent spraying at 7 o'clock in the morning.

THOROUGHNESS.

In spraying for any pest on citrus trees the complete wetting of every leaf on both surfaces as well as the branches and trunk should be accomplished. It is only when leaves are hit by the spray that the pests on them are killed. Lack of thoroughness in this respect is responsible for more failures to obtain satisfactory results than are all other factors combined.

In order that satisfactory results may be secured, only the most intelligent, honest, and careful laborers should be employed to handle the spray rods. In fact, it might be well for the foreman or owner to handle one rod. If this is not practicable, the owner or a responsible foreman should be with the machine all the time. It is also advisable to examine the leaves frequently to see if they have been hit on the lower surfaces. The sprayer himself should have an opportunity to examine his own work. Even when the best and most thorough work has been done, many leaves will remain untouched by the spray.

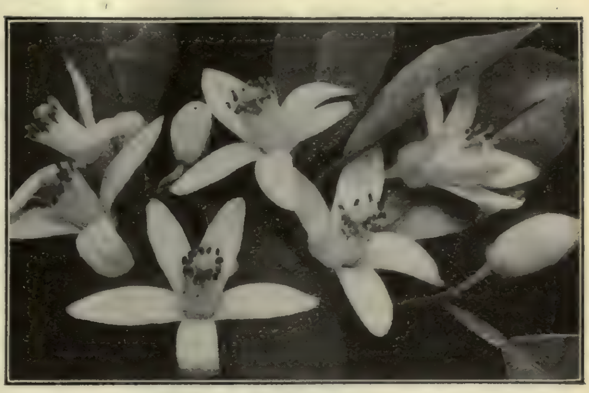

FIG. 17.—Normal orange blooms and buds. Compare with the bloom in figure 18.

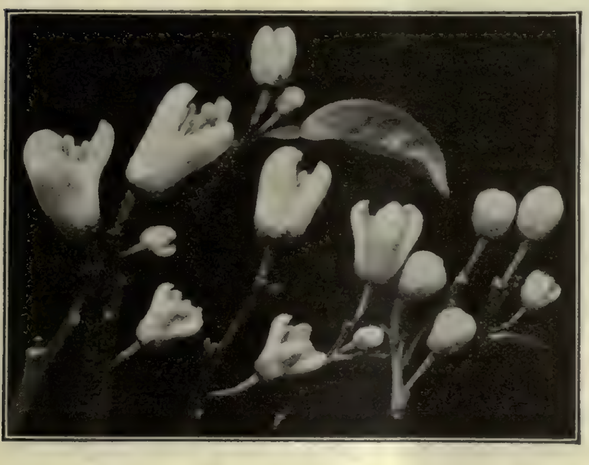

FIG. 18.—Spraying with heavy oil emulsions at full strength may injure the bloom of orange and grapefruit, as here illustrated, and cause much of it to drop.

WHEN TO SPRAY.

So far as the effect of the various insecticides on the trees and fruit is concerned it is reasonably safe to spray at any season of the year. The oil emulsions, however, should not be used at more than half strength during the blossoming period (compare figs. 17 and 18) or until the fruit is about an inch in diameter. Although the writer has known several people to use them at this season at full strength without any injurious results, the application of oil sprays to the blossoms is too hazardous to be generally practiced. When low temperatures follow the application of oil sprays, an excessive shedding of foliage usually occurs. Spraying operations that are being carried on during the winter should be discontinued as soon as a cold wave is predicted. The sulphur sprays, either alone or in combination with the tobacco solutions, usually will cause no damage to the blossoms if used at any recommended strength. Neither will the tobacco solutions cause any damage to the blossoms even if used at several times the recommended strength. If it is the intention to spray during the winter, it will be found much more convenient to spray after the fruit has been removed. The insecticide usually will do no harm to the fruit, but the spraying operations may cause more or less mechanical injury when the branches are heavily laden with fruit. It is also difficult to do as thorough work when the branches are weighted with fruit.

So far as the effectiveness of the various insecticides on the different stages of the insects and mites is concerned, it is about as great at one time as at another. The white flies and scale insects can be killed both in the summer and during the winter, either in the mature or in the immature stages. The mites also can be killed at any time they may be present.

The life history and habits of nearly all pests on citrus trees are, fortunately, such that good and satisfactory results can be obtained at any time the spray is applied, but to obtain the maximum benefit with the minimum expense the spraying must be opportune. Much of the spraying done at present brings no returns to the grower, because it is done after the damage has taken place. The writer has seen many groves being sprayed when the purple scale had already done $2 worth of damage per tree. Men also have been seen spraying where the pests were so few that practically no beneficial results would ever follow the treatment. *The spraying for rust mites is often done when not more than two or three mites can be found on a fruit, or after they have become so numerous that the russeting has already appeared and could not be prevented by any amount of spraying.*

As a general rule, the time to spray for the control of pests on citrus trees is when they are present in such numbers that if left to reproduce without artificial hindrance they would soon become injurious. The pests should not be allowed to increase to a point where they attract noticeable attention, as in figure 19. In case the various pests of citrus trees are permitted to become so abundant as to cause damage, the profits which might be derived from artificial treatment, such as spraying, are to a certain extent lost.

Specifically then, what should guide the citrus grower in deciding just when spraying should be done or if it should be done at all? It must be confessed that it is most difficult to answer such a question. This difficulty arises from the fact that the extent of the future infestation of any pest is so influenced by weather conditions and natural enemies that it is impossible to make predictions approximating any degree of accuracy. A few suggestions are given here to help the intelligent grower to handle this most difficult of all problems.

Six-spotted mite.—In the control of the six-spotted mite spraying should be done if one or two trees are badly infested in March, April, or May, or if many trees are slightly infested. This pest spreads most rapidly in the dry spring months, and complete defoliation often follows while the grower is contemplating spraying. After the rainy season sets in trouble is rarely experienced with this species.

Rust mite.—The rust mite, being of small size, often reaches the maximum infestation before the growers know of its presence. The first intimation of its presence is evidenced by the "russet" fruit, and then it is too late to remedy the damage. The grower should provide himself with a hand lens to enable him to see this serious pest. If there are about 50 mites on each of the old leaves in the spring, spraying should be done within the next few days. Another rule to follow is to spray when the mites are abundant on the foliage and just beginning to appear on the young fruit. If the fruit is about 1½ inches in diameter and a few fruits per tree look a little brownish, the time is short before spraying should be started to get bright fruit. If in the spring of the year, in either April, May, or June, from 100 to 200 mites are on each fruit, spraying should be given within

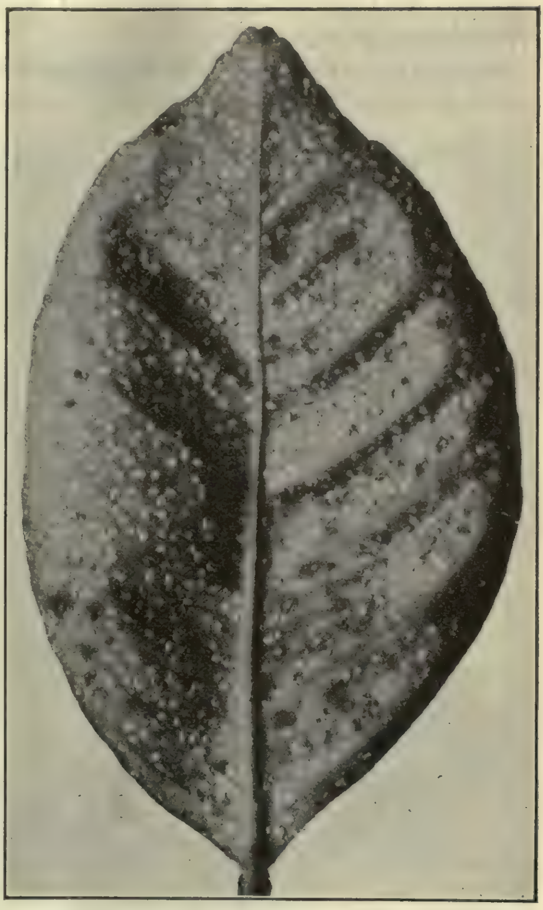

FIG. 19.—An orange leaf heavily infested with the citrus white fly. There are over 800 pupæ and pupa cases on this leaf. The white fly should never be permitted to become as abundant as here shown. (Morrill and Back.)

the next two weeks. At other times a greater number could be present without russeting the fruit.

Scale insects.—For scales spraying should be done before any of the limbs or branches are killed or any of the leaves have turned yellow. No trees should be left until the center is killed out before treatment is given.

White flies.—The object in spraying for white flies should be to keep the sooty mold (figs. 20 and 21) from both the leaves and fruit. When each leaf has an average of from 6 to 10 pupæ in the spring, spraying should by all means be given in May. Unless the grower has acquired considerable judgment as to when spraying should be done, it might be well to follow some such scheme as here given.

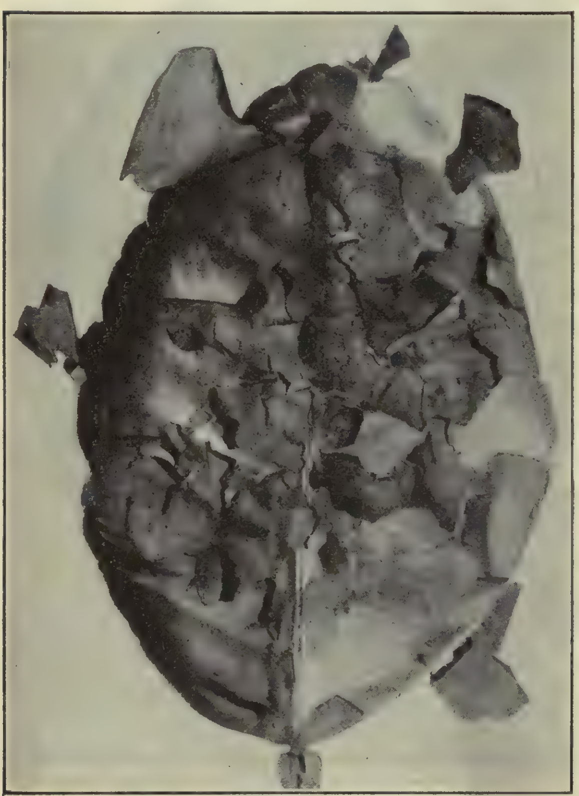

FIG. 20.—Miscible-oil sprays cause the sooty mold following white-fly attack to break and fall from the foliage and branches. A strong breeze or heavy rain two or three days after trees have been sprayed usually will take off all or nearly all the smooty mold from the tree. (Morrill and Back.)

SPRAYING SCHEDULE RECOMMENDED.

The following spraying scheme has been used extensively for four years and generally has given satisfactory results. No hard and fast scheme can be given, however, and the number of sprayings depends to a large extent on the thoroughness of the work and the abundance of the pests.

1.—Paraffin-oil emulsions: Government formula, 1 per cent of oil—May: The main object of spraying at this time is to kill white flies, scale insects, and to a large extent rust mites, although this treatment must not be relied upon to control the last pest. The spraying should be given after the adults of the first brood of white flies have disappeared and before the appearance of those of the second brood. The fruit should be an inch or more in diameter. This treatment should be given before the beginning of the rainy season, so that the beneficial fungi will attack those insects which are not killed by the spray.

2.—Lime-sulphur solution, 32° Baumé, 1–50 to 1–75—June to July: The main object of this treatment is to kill rust mites, and the best time for its application varies with the appearance of the maximum number of rust mites. It should be applied before the mites get very abundant and before russeting appears. It will also kill some scales and white flies, but is of little value for that purpose.

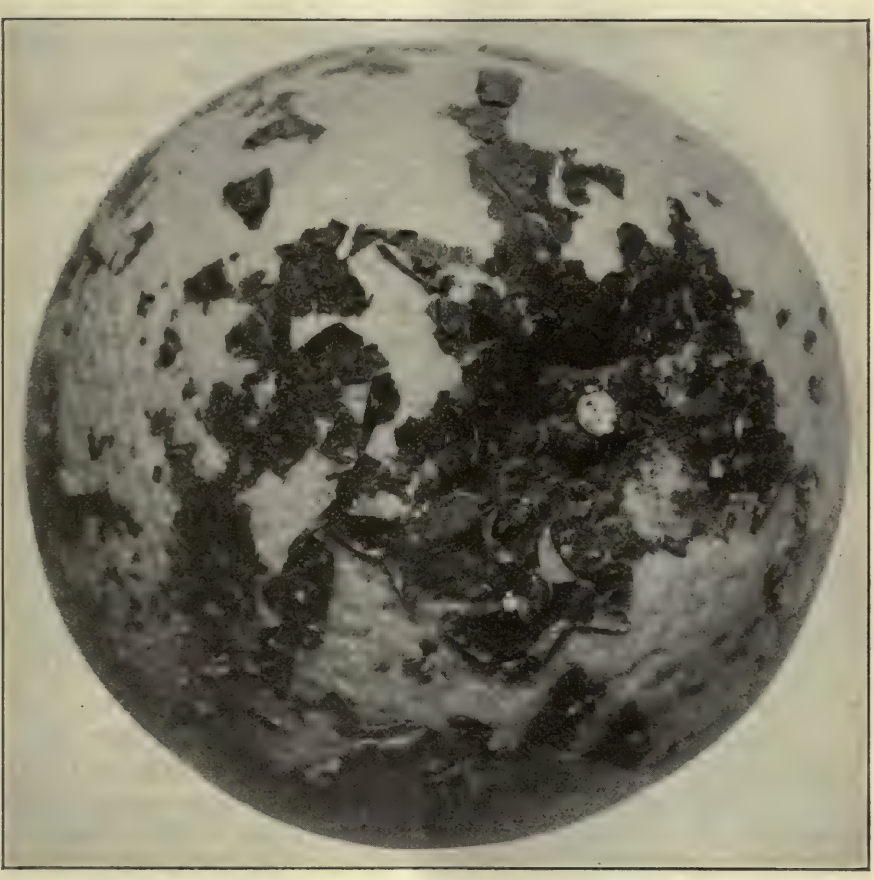

FIG. 21.—Heavy coatings of sooty mold on oranges and grapefruit prevent the fruit from coloring normally. The rind remains green beneath the layers of sooty mold. Spraying with a miscible oil breaks up the sooty mold as illustrated, thus giving the sun a chance to color the fruit.

3.—Paraffin-oil emulsions: Government formula, 1 per cent of oil—August 25 to October 31: This is the second spraying for the white fly and scale insects. The object of spraying at this time is to kill all the white-fly larvæ which are the progeny of the third and last brood. It is this brood which causes nearly all the damage from the white flies, and the earlier they are killed the better it is for the tree. This will also remove the sooty mold from the leaves (fig. 20) and from the fruit (fig. 21) so that the sun can color the fruit. Soda-sulphur, 1–50, may be added to this spray to increase its effectiveness in killing rust mites.

4.—Lime-sulphur solution, 32° Baumé, 1–50 to 1–75—November or December: The object of this spraying is to kill rust mites, and it may or may not be necessary, depending on the abundance of the mites.

It may be necessary to spray for rust mites and red spiders before number one is given. This is especially true for grapefruit in the more southern counties of Florida. If such a spraying is given, it should be given in the midst of the blossoming period, using lime-sulphur 1–40, which will kill rust mites, red spiders, and young scales. It is advisable to add nicotine sulphate 1–1,200 if thrips are abundant. It may also be necessary to spray three times with the oil sprays, in which case this treatment can be given in midsummer or in winter. If the red scale is very abundant, two sprayings with the oil emulsions should be given at intervals of about a month.

THE EFFECT OF INSECTICIDES ON PESTS.

The fish-oil soap and the oil sprays kill the insects by asphyxiating them. The oil sprays kill the adults, eggs, larvæ, and pupæ of the white flies. It is not difficult to determine whether the larvæ and pupæ of the white flies have been killed, for they turn brownish 3 to 10 days after the spray has been applied. (Fig. 22.) They also brush from the leaf easily. A month or more afterwards those which have been killed are quite brown and somewhat dried up.

The oil sprays kill all stages of the purple scale, and in many cases all the eggs of some females are prevented from hatching. In other cases the oil enters the opening in the rear of the scale covering and prevents a row or two of eggs nearest the opening from hatching. In the natural course of events the eggs nearest the opening hatch first, since they were deposited first. This gives those young scales that hatch from eggs farther from the opening plenty of opportunity to emerge. When the first row or two of eggs is prevented from hatching, the exit is stopped. This prevents those young scales from emerging that hatch from eggs not affected by the oil film. Thus almost complete mortality results.

The oil spray kills the young stages of the red scale and in most cases the adult females, but the scale covering is fastened so closely to the leaf or fruit that the eggs are seldom harmed. A second spraying must be given after these hatch and develop into the young stages.

The sulphur sprays are extremely effective in killing rust mites. The action is rapid, the bodies of the mites being largely destroyed by the caustic nature of the spray. When on the fruit, a few are washed to where the drop of spray collects and there their dried bodies may be seen after the spray has evaporated. The eggs also are killed if the spray is used at the recommended dilutions.

The sulphur sprays are very effective, also, in killing the purple and six-spotted mites. The killing action is rapid, but the bodies are not completely destroyed by the caustic nature of the spray as is the case with rust mites. The spray does not prevent the eggs from hatching, but the presence of the spray usually kills the young mite as soon as it emerges from its eggshell. Thousands of newly hatched dead mites have been observed near the eggshell from which they had just emerged. While the oil sprays usually prevent an egg from hatching, the sulphur sprays more often kill the young "crawler" as soon as it hatches.

Sulphur when used in a fine state with hydrated lime also kills six-spotted and rust mites. When six-spotted mites come in contact with fine sulphur they become exceedingly active at first, run about in a perfectly wild and aimless manner, then gradually become quiet, and finally die. All mites, so far as known, are extremely sensitive to sulphur in any form.

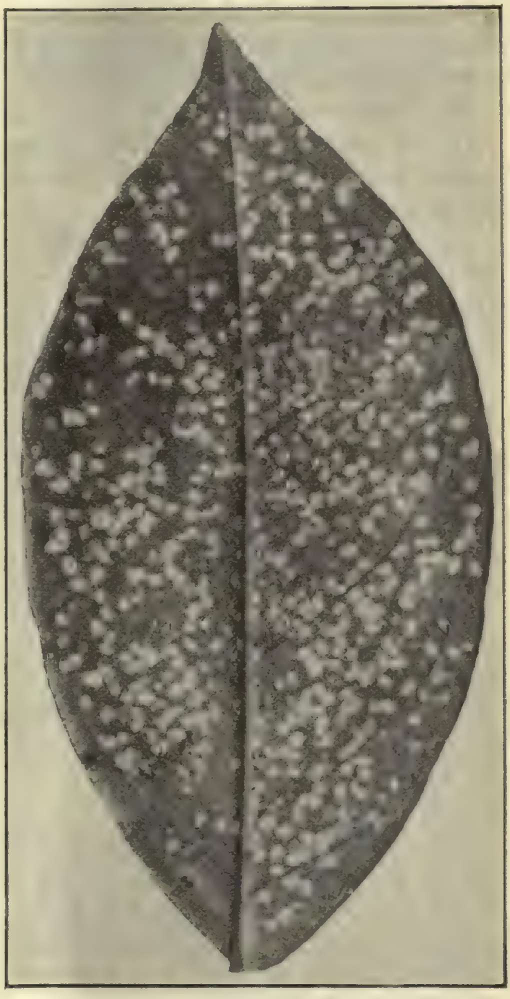

FIG. 22.—Pupæ of the citrus white fly. When living the pupæ are seen with difficulty, but after they have been killed, as in the illustration, they turn brown and one can then easily see how thin and scalelike they really are. (Morrill and Back.)

SPRAY INJURIES.

Under average conditions of temperature and moisture the oil sprays will not cause any noticeable injury to either the foliage or the fruit. New growth often starts in a few days after the killing of the insects. A large percentage of old leaves, now functionless, fall about the third day following the application of an oil spray. Good leaves very seldom fall. In the experiments 2 per cent of oil, or twice as much as required, has been used extensively without causing normal leaves to fall prematurely. In small tests 3 per cent of oil in the diluted spray material caused no damage. No injury follows spraying either before or during a rain and neither does humidity appear to be a factor in causing injury. When the oil emulsions are used, whether made of kerosene or heavy lubricating oil of 24° Baumé, shadows sometimes appear on the fruit. These shadows usually follow spraying during hot, bright days when the temperature is above 91° or 92° F. As the temperature is very high, the heat evaporates the water in the spray material before it has had time to run off. This concentrates the oil in one spot and causes a slight damage to the stomata, resulting in a darker shade of green than the surrounding area. These dark-green shadows disappear not later than a week or two after the fruit has colored in the fall and it is impossible to locate the previous discolorations if these have not been marked. Sometimes the damage is localized to the spot where the drop of spray has collected. The only way to avoid such damage would be to cease spraying when the temperature rose above 92°. This injury occurs only occasionally.

The application of the oil sprays two or three times a year at the recommended strength has never been known to cause devitalization of the trees. If an excessive amount of spray is used the normal growth of the leaves is interrupted. They do not reach the proper size, become thin, and the tree has the appearance of being stunted. The fruit also is small, does not color up properly or at the proper time, and is sour when other fruit is sweet. Such a condition only follows the application of from three to six times as much oil as the worst infestation of white flies and scale insects requires. Two applications within one month of a 2 per cent solution in 1916 did no noticeable damage to either the tree or the fruit.

Soda-sulphur solution very seldom, if ever, causes any damage to the trees or fruit. No accumulated ill effects have been known to follow the use of this spray. This noninjuriousness is no doubt due to its lack of stability since it is easily washed off by rains and dissipated by dews.

Lime-sulphur solution does not cause damage at the recommended dilutions under average conditions. When the temperature is 92° F. and the sun is bright, injury to the fruit sometimes follows, but this does not often occur. In all the experimental work such injury followed on only one occasion. The injury is always located on the side of the fruit turned to the sun at the particular time of day when the spraying was done. The exact cause of this type of injury is not yet fully understood, but it is very certain that it should not be considered as being due to the insecticide alone, but to the combined action of the sun and the insecticide. When the injury is caused by the insecticide alone, the blemish will be found at places where the drop of spray collects on the lower surface of each fruit.

Instead of injuring citrus trees, lime-sulphur solution has a stimulating effect. The leaves become a darker green and the fruit reaches a larger size. Fruit has been known to ripen at least three weeks to a month earlier than other fruit of the same kind in an adjoining row. The exact cause of this is not known, but the spray evidently has some direct action on the leaves. Careful experiments have shown that there is no known spray so beneficial to citrus trees as is lime-sulphur solution.

COST OF SPRAYING.

The cost of spraying (Table I) necessarily varies and depends upon the size of the trees, the density of the foliage, the equipment used, and the nearness of the grove to the water supply. Accurate estimates of the probable cost can be computed only after all these factors have been taken into consideration. Nursery trees can be sprayed for one-sixth of a cent each, while the largest trees will cost as much as 10 cents. Trees with dense foliage require much more insecticide and a longer time to spray than those with sparse foliage, even though the latter may be much larger trees. If the spraying is done with a barrel pump the cost will be somewhat greater than if done with a power outfit. The item of labor will be not far from 75 per cent of the total cost. If the water supply is in the grove or very close, the cost will be considerably less than if it is some distance away. A water supply a greater distance away than half a mile is not practicable, because it would require two extra teams to supply one machine. This would increase the cost about 1½ cents per tree.

In computing the cost of spraying the depreciation of machinery should always be included. Many inquiries were sent to citrus growers for information on this point. Some estimated the depreciation to be as great as 25 per cent. One grower thought it would be as low as 10 per cent, but it was the opinion of the majority that from 15 to 20 per cent would be more consistent. This appeals to the writer as the proper estimate to be placed upon this phase of the cost of spraying. The percentage of depreciation will depend almost entirely upon the care that is given the machine. The length of time a machine will be serviceable depends much more upon the care it receives than upon the amount of work it does.

The writer has obtained from many growers the actual cost figures for spraying done on a commercial basis under the average grove conditions prevailing in Florida. These will assist any grower contemplating a spraying program in arriving at an accurate estimate of the probable cost. These statements include the depreciation of machinery as well as cost of labor, team hire, insecticides, and incidentals, but naturally can not be construed to apply to such unusual conditions as those bearing on a local shortage in chemicals due to unprecedented freight congestion, or to a deficiency in the supply of the chemicals in the United States generally.

TABLE I.—*Cost of spraying.*

Grove No.	Size of trees in boxes of fruit.	Acres.	Number of trees.	Applications per year.	Cost.			Distribution of cost.			Incidentals.	Remarks.
					Per box.	Per tree.	Per acre.	Insecticides.	Labor.	Team.		
								P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	
1	10	7½	450	7	......	0.50	$30.00	......	......	......	......	
2	12	......	4,316	1	......	.097	......	34	29.4	32	4.5	
3	12	......	1,239	3	0.0267	.109	......	26	28	35	11	
4	15	......	300	5	.050	.66	......	......	......	......	......	
5	8	10	650	2	.056	......	11.00	40	......	......	......	
6	10	260	......	5	.0438	......	......	......	......	......	......	
7	10	......	6,367	5	......	.21½	......	46	......	......	......	
8	10	10	650	3	......	.21½	14.00	48	......	......	......	
9	10	260	......	5	.06	......	......	50	......	......	......	
10	7	300	......	......	.06	......	......	......	......	......	......	
11	8	......	1,000	1	......	.08	......	......	......	......	......	
12	8	40	......	4	.055	......	......	......	......	......	......	
13	10	550	......	1	......	......	3.00	......	......	......	......	
14	18	35	......	6	.05	......	......	......	......	......	......	
15	10	......	1,909	1	......	.08	......	44	35	21	......	
16	10	......	1,800	1	......	.083	......	......	......	......	......	
17	8	60	......	4	.05	.16	......	......	......	......	......	
18	8	120	6,360	4	.06	.20	......	64	36	......	......	
19	8	20	1,600	1	......	.06	......	45	55	......	......	
20	8	......	2,125	1	......	.08	......	57	36	......	7	
21	8	......	1,343	1	......	.78	......	24	65	......	11	
22	8	......	......	3	......	.15	......	......	......	......	......	
23	......	......	400	1	.022	.76	......	19	68	13	......	Hand pump.
24	5	......	778	3	......	.194	......	36	64	......	......	1914 pump.
25	5	......	778	3	......	.20	......	27	73	......	......	1915 pump.
26	7	......	500	1	.29	......	......	25	35	30	......	

The figures of Table I show that it will cost from $3 to $5.50 per acre per application to spray the average bearing grove. The cost per box is also seen to be from 1 to 1½ cents for each application and the cost per tree from 5 to 10 cents. To carry out any annual spraying schedule it will cost about 6 cents per box, 20 cents per tree, and about $15 per acre. The cost of spraying young trees is very small. One nurseryman sprayed 40,000 trees with the oil spray for less than one-sixth of a cent each. Young grove trees from 1 to 3 years old can be sprayed for about 1 cent each.

PROFITS FROM SPRAYING.

After many years of work it is still impossible to express the percentage of profits to be expected on money expended in spraying for the control of citrus pests. This same condition, however, applies to every grove operation in Florida. The profits which may arise from following a spraying schedule are due to the raising of the grade of the fruit and increasing the yield by preventing the devitalization of the trees following insect attack. (Compare figs. 23 and 24.) A detailed statement of the profits a grower should expect from spraying has been published in Department Bulletin 645, "Some Reasons for Spraying Citrus Trees in Florida," and the reader is referred to that publication for the complete discussion of this phase of the spraying question.

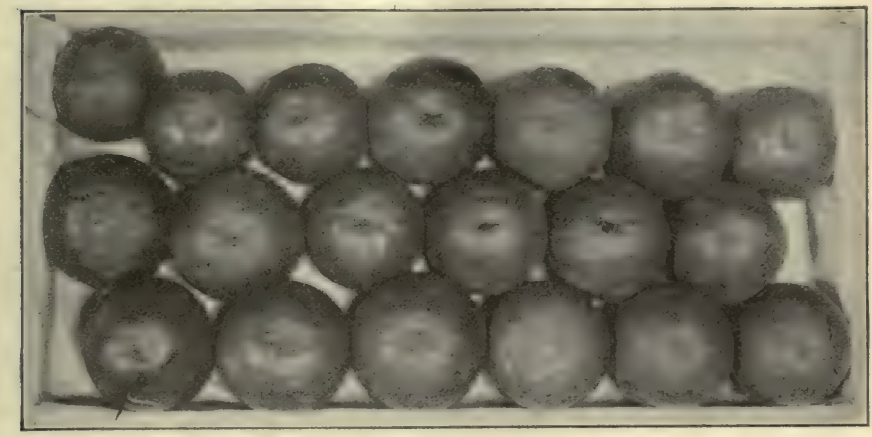

FIG. 23.—A miscellaneous lot of fruit picked from trees sprayed to kill rust mites. Only 19 fruits could be packed in the tray. Compare fruits shown in figure 24.

In that bulletin it was shown that in the 1915–16 citrus crop there was a loss of over $500,000 due to the lowering of the grades of the fruit, caused by pests, which could have been prevented very easily. The reduction in size caused an additional loss of $475,000, and the reduction in yield caused a loss of $760,000, making a total of $1,744,955, practically all of which could have been prevented easily at a nominal cost. To spray this crop at 6 cents per box would have cost $456,000, leaving a profit of $1,288,955, or 282.7 per cent profit on the investment.

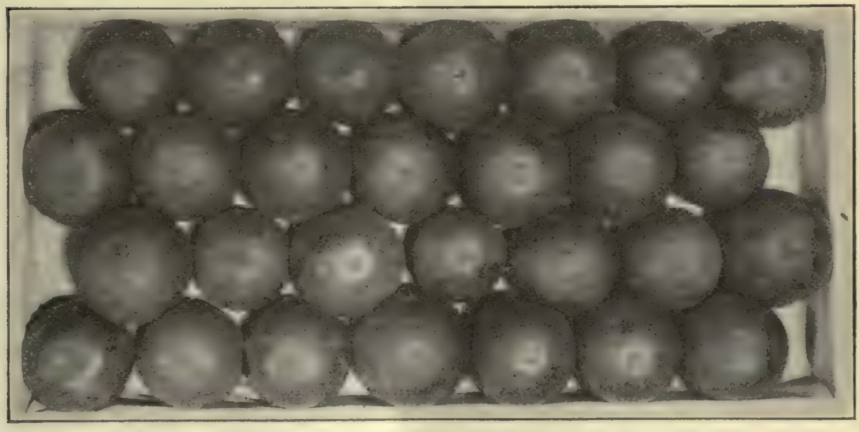

FIG. 24.—A miscellaneous lot of oranges from unsprayed trees adjoining sprayed ones. Note that these 28 fruits take up the same space as the 19 fruits from sprayed trees shown in figure 23. Spraying increases the size of the fruit.

In addition to these profits there are benefits that can not be expressed in a money unit. The better the fruit, the greater its marketability. High-grade fruit can be sold when the owner desires to sell it; the lower grades can be sold when the buyers want it, or when the market calls for the lower grades. Many growers consider this a most important item. There is much satisfaction in growing fine fruit and owning healthy trees. This makes orange growing fascinating.

PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE RELATING TO INSECTS INJURIOUS TO CITRUS AND OTHER SUBTROPICAL FRUITS.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Control of the Citrus Thrips in California and Arizona. (Farmers' Bulletin 674.)
Carbon Disulphid as an Insecticide. (Farmers' Bulletin 799.)
Common Mealybug and its Control in California. (Farmers' Bulletin 862.)
Fumigation of Ornamental Greenhouse Plants with Hydrocyanic-acid Gas. (Farmers' Bulletin 880.)
Fumigation of Citrus Trees. (Farmers' Bulletin 923.)
Control of the Argentine Ant in Orange Groves. (Farmers' Bulletin 928.)
Spraying for the Control of Insects and Mites Attacking Citrus Trees in Florida. (Farmers' Bulletin 933.)
Citrus Fruit Insects in Mediterranean Countries. (Department Bulletin 134.)
The Mediterranean Fruit Fly in Bermuda. (Department Bulletin 161.)
Argentine Ant: Distribution and Control in the United States. (Department Bulletin 377.)
The Citrus Thrips. (Department Bulletin 616.)
The Mediterranean Fruit Fly. (Department Bulletin 640.)
Some Reasons for Spraying to Control Insect and Mite Enemies of Citrus Trees in Florida. (Department Bulletin 645.)
The Argentine Ant in Relation to Citrus Orchards. (Department Bulletin 647.)
Preparations for Winter Fumigation for Citrus White Fly. (Entomology Circular 111.)
Spraying for White Flies in Florida. (Entomology Circular 168.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Katydids Injurious to Oranges in California. (Department Bulletin 256.) Price, 10 cents.
The Melon Fly in Hawaii. (Department Bulletin 491.) Price, 25 cents.
Fumigation of Ornamental Greenhouse Plants with Hydrocyanic-acid Gas. (Department Bulletin 513.) Price, 5 cents.
The Mediterranean Fruit Fly in Hawaii. (Department Bulletin 536.) Price, 30 cents.
Mango Weevil. (Entomology Circular 141.) 1911. Price, 5 cents.
Fumigation for Citrus White Fly, as Adapted to Florida Conditions. (Entomology Bulletin 76.) 1908. Price, 15 cents.
Fumigation Investigations in California. (Entomology Bulletin 79.) 1909. Price, 15 cents.
Hydrocyanic-acid Gas Fumigation in California. (Entomology Bulletin 90, 3 pts.) 1913. Price, 20 cents.
Fumigation of Citrus Trees. (Entomology Bulletin 90, pt. I.) 1913. Price, 20 cents.
Value of Sodium Cyanid for Fumigation Purposes. (Entomology Bulletin 90, pt. II.) 1913. Price, 5 cents.
Chemistry of Fumigation with Hydrocyanic-acid Gas. (Entomology Bulletin 90, pt. III.) 1913. Price, 5 cents.
White Flies Injurious to Citrus in Florida. (Entomology Bulletin 92.) 1911. Price, 25 cents.
Orange Thrips, Report of Progress. (Entomology Bulletin 99, pt. I.) 1911. Price, 5 cents.
Red-banded Thrips. (Entomology Bulletin 99, pt. II.) 1912. Price, 5 cents.
Natural Control of White Flies in Florida. (Entomology Bulletin 102.) 1912. Price, 20 cents.

HOME GARDENING IN THE SOUTH

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FARMERS' BULLETIN 934

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. February, 1918

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A WELL-KEPT vegetable garden is a source not only of profit to the gardener but of pleasure to the entire family. For many vegetables which deteriorate rapidly in quality after being gathered, the only practicable means of securing the best is to grow them at home. This is especially true of garden peas, sweet corn, string beans, green Lima beans, and asparagus.

The land utilized for the farm garden, if well cared for, yields much larger returns than any area of similar size planted to the usual farm crops. A half-acre garden should produce as much in money value as 2 or 3 acres in general farm crops.

In most sections of the South, though vegetables can be grown in nearly every month of the year, the garden is neglected; in fact, no feature of southern agriculture is more neglected than the production of vegetables for home use.

In the following pages specific instructions are given for making a garden and caring for it throughout the season.

HOME GARDENING IN THE SOUTH.

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IMPORTANCE OF THE HOME GARDEN.

IN REGIONS where cotton is the principal crop a well-kept garden is the exception, and even in localities where commercial vegetable production is the main industry there is a scarcity of fresh vegetables during a large part of the year. Growing one crop to the exclusion of all others tends to impoverish a community, because it necessitates sending money out of the community for many of the necessities of life which can and should be produced at home. The farmer who buys vegetables is not only paying the cost of production but is also paying the cost of transportation and marketing. Even if vegetables sometimes can be bought more cheaply than they can be produced by the farmer, yet it is desirable to have a home garden. It is not always possible to buy vegetables in country communities, and those that can be secured are usually stale and inferior in quality to the home-grown product.

Fresh vegetables in many cases make up a very small part of the diet of the southern farmer's family. It is impossible to make an accurate estimate of the value of the vegetables which may be grown in home gardens in the South, but a well-kept garden will yield a return several times as great as the return from an equal area devoted to cotton or other general farm crops. Of even greater importance than the money value of the products of the garden is the satisfaction of having a bountiful supply of vegetables close at hand, where they can be secured at a moment's notice.

Vegetables and fruits furnish a large part of the essential salts which are absolutely necessary to the well being of the human system, so that the value of vegetables in the diet is a great deal more than the mere food or money value. The need of tonics and other medicines in the spring is due largely to the lack of vegetables and fruit in the winter diet. If more succulent food were available, less money would be spent in doctor's fees and for medicines.

Fresh vegetables from the home garden have not been subjected to exposure on the market and are not liable to infection. Many vegetables lose their characteristic flavor within a few hours after gathering. The home vegetable garden is worthy of greatly increased attention by the southern farmer, and a larger number and greater variety of crops should be grown in the garden.

This bulletin gives suggestions as to the location, plan, and arrangement of a home garden, the soil and its preparation, manures and fertilizers, and the seeds and plants to use, together with brief descriptions of the specific methods of handling the more important vegetables and recommendations as to the varieties to plant in order to secure a varied and continuous supply throughout the year.

LOCATION OF THE GARDEN.

As the work of caring for the garden is usually done in spare time it should be located as near the house as possible. A slope to the south or southeast is usually preferable, because here the soil warms up early in the spring, which permits early planting and stimulates the early growth of crops. Practically any type of soil can be used for the garden, but a sandy loam is to be preferred.

Good drainage is of prime importance. The land should have sufficient fall to drain off surplus water during heavy rains, but the fall should not be so great as to wash the soil. If the land near the house is level, artificial drainage should be employed. Open ditches or tile drains will be satisfactory. On level land that is not artificially drained it is necessary to plant on ridges or in beds in order to prevent drowning the crops during wet weather. The ridges or beds should be as wide and flat as conditions will allow, for narrow, sharp ridges dry out quickly.

PLAN AND ARRANGEMENT OF THE GARDEN.

It would be impossible to give a specific scheme of arrangement for a garden that would suit all conditions, and the plans here presented are only suggestive. Each grower should devise a plan to suit his own conditions, but it is hoped that the suggestions given in figures 1 and 2 will be helpful. The gardener should study the area to be used for the garden and then lay it out on paper, as this will save time in planting.

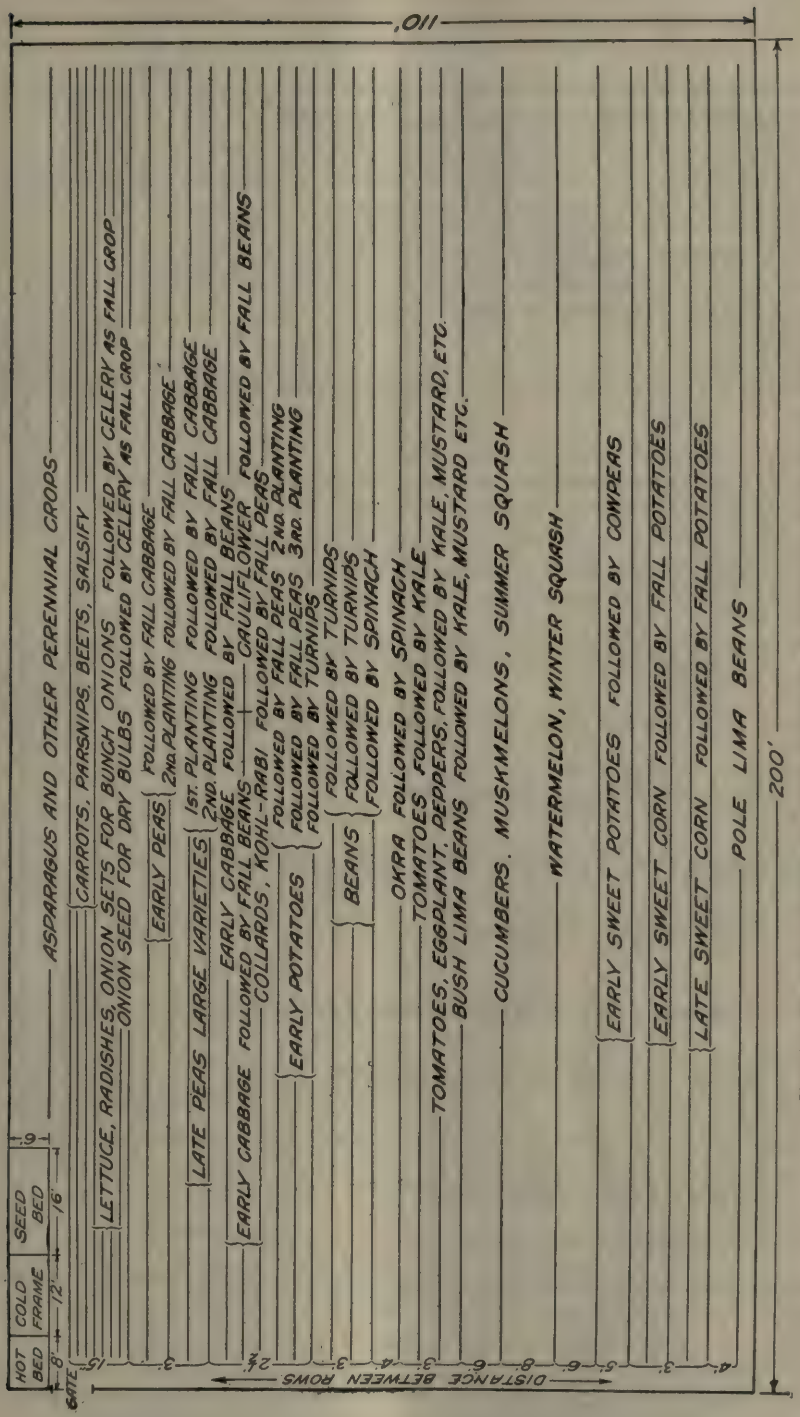
110'
HOT BED
COLD FRAME
SEED BED
8'
12'
16'
6'
ASPARAGUS AND OTHER PERENNIAL CROPS
CARROTS, PARSNIPS, BEETS, SALSIFY
LETTUCE, RADISHES, ONION SETS FOR BUNCH ONIONS FOLLOWED BY CELERY AS FALL CROP
ONION SEED FOR DRY BULBS FOLLOWED BY CELERY AS FALL CROP
EARLY PEAS
FOLLOWED BY FALL CABBAGE
2ND. PLANTING FOLLOWED BY FALL CABBAGE
LATE PEAS LARGE VARIETIES
1ST. PLANTING FOLLOWED BY FALL CABBAGE
2ND. PLANTING FOLLOWED BY FALL CABBAGE
EARLY CABBAGE FOLLOWED BY FALL BEANS
CAULIFLOWER FOLLOWED BY FALL BEANS
EARLY CABBAGE FOLLOWED BY FALL BEANS
COLLARDS, KOHL-RABI FOLLOWED BY FALL PEAS
EARLY POTATOES
FOLLOWED BY FALL PEAS 2ND. PLANTING
FOLLOWED BY FALL PEAS 3RD. PLANTING
FOLLOWED BY TURNIPS
BEANS
FOLLOWED BY TURNIPS
FOLLOWED BY TURNIPS
FOLLOWED BY SPINACH
OKRA FOLLOWED BY SPINACH
TOMATOES FOLLOWED BY KALE
TOMATOES, EGGPLANT, PEPPERS, FOLLOWED BY KALE, MUSTARD, ETC.
BUSH LIMA BEANS FOLLOWED BY KALE, MUSTARD ETC.
CUCUMBERS, MUSKMELONS, SUMMER SQUASH
WATERMELON, WINTER SQUASH
EARLY SWEET POTATOES FOLLOWED BY COWPEAS
EARLY SWEET CORN FOLLOWED BY FALL POTATOES
LATE SWEET CORN FOLLOWED BY FALL POTATOES
POLE LIMA BEANS
200'
GATE
15'
3'
3'
2½'
3'
4'
3'
6'
8'
6'
5'
3'
4'
DISTANCE BETWEEN ROWS

FIG. 1.—Plan of a half-acre garden, showing the location and succession of crops.

By following a plan the gardener will be better able to utilize his land. In most sections of the South it is possible to grow two or three crops on the same land in one season, and it is better to do this rather than to grow only one crop, even if land is plentiful.

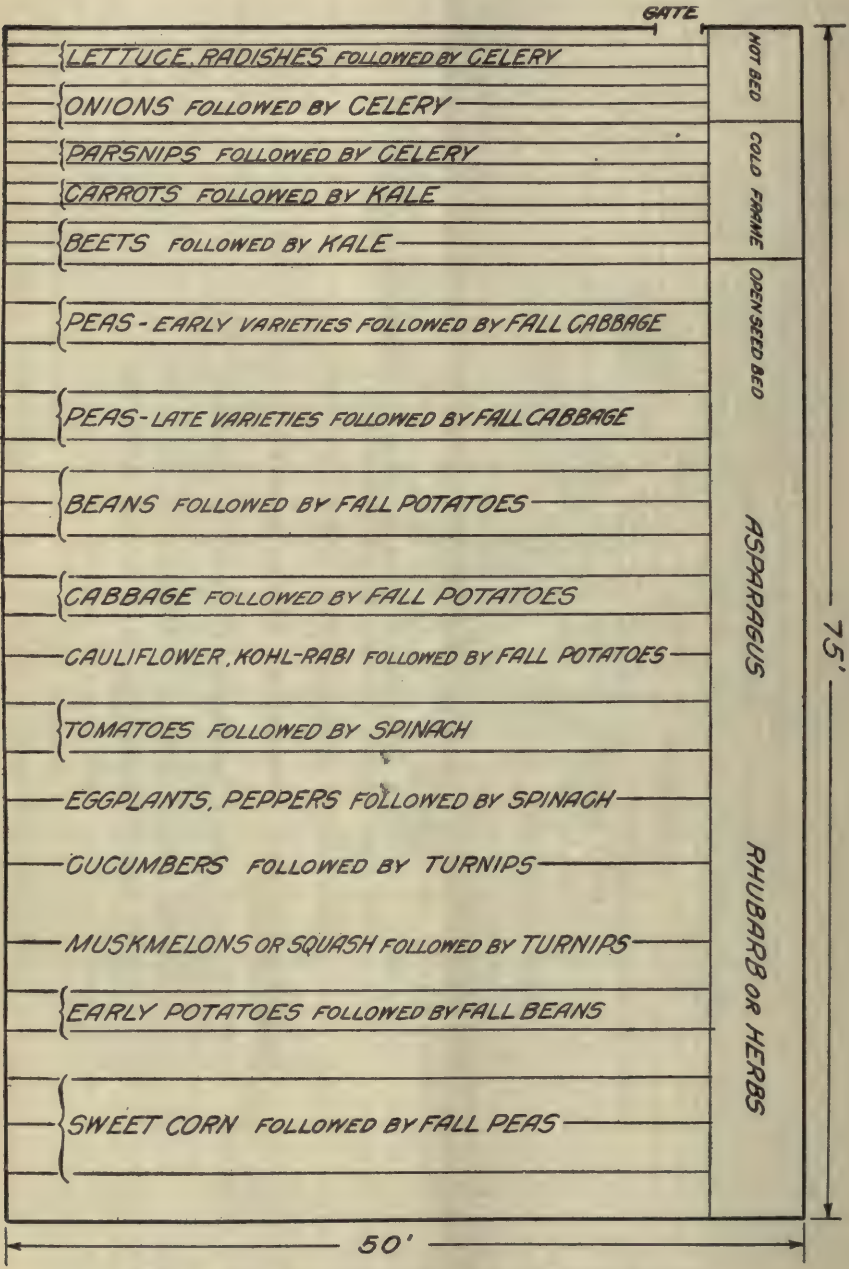
GATE
LETTUCE, RADISHES FOLLOWED BY CELERY
ONIONS FOLLOWED BY CELERY
PARSNIPS FOLLOWED BY CELERY
CARROTS FOLLOWED BY KALE
BEETS FOLLOWED BY KALE
PEAS - EARLY VARIETIES FOLLOWED BY FALL CABBAGE
PEAS - LATE VARIETIES FOLLOWED BY FALL CABBAGE
BEANS FOLLOWED BY FALL POTATOES
CABBAGE FOLLOWED BY FALL POTATOES
CAULIFLOWER, KOHL-RABI FOLLOWED BY FALL POTATOES
TOMATOES FOLLOWED BY SPINACH
EGGPLANTS, PEPPERS FOLLOWED BY SPINACH
CUCUMBERS FOLLOWED BY TURNIPS
MUSKMELONS OR SQUASH FOLLOWED BY TURNIPS
EARLY POTATOES FOLLOWED BY FALL BEANS
SWEET CORN FOLLOWED BY FALL PEAS
HOT BED
COLD FRAME
OPEN SEED BED
ASPARAGUS
RHUBARB OR HERBS
75'
50'

FIG. 2.—Plan of a small garden to be cultivated by hand.

In planning a garden the kind of cultivation to be used should be considered. Horse cultivation is recommended whenever possible, because it saves handwork and is cheaper. Where the work is to be done mainly by means of horse tools, the garden should be long and narrow, with the rows running the long way. The garden should have no paths across the rows, but sufficient turning spaces should be left at the ends. For hand cultivation, the rows can be much closer together and may run across the garden. In the plans shown as figures 1 and 2, where the distance between the rows is less than 2 feet hand cultivation with a wheel hoe is contemplated. If a hand cultivator or wheel hoe is not available, the rows should be at least 2 feet apart to give sufficient space for the horse cultivator. Straight lines should be followed, no matter what method of cultivation is used.

The size of the garden depends upon the number of persons to be supplied. One-fourth to one-half an acre is sufficient for an average family and should produce enough vegetables for use throughout the year. By close attention to the rotation of crops, the succession of crops, and interplanting, one-fourth of an acre may be made to supply a family of six. Where land is available, it is recommended that a sufficient area be set aside to allow part of the garden to be planted to a soil-improving crop each year.

Just what vegetables are to be grown depends, of course, on the individual tastes of the family. It would be a waste of time and space to grow crops not desired by the family. In general, the aim should be to grow those vegetables in which freshness is an important consideration. Beans, peas, Lima beans, sweet corn, and asparagus, for example, lose much if they are not cooked almost immediately after they are gathered. Potatoes, on the other hand, do not deteriorate rapidly, and as good ones can be bought as can be grown in the home garden. Moreover, potatoes occupy a large area in proportion to their yield and should not be grown in a small garden where the area is not sufficient to produce all the vegetables needed by the family. This is also true of sweet corn, peas, cucumbers, and melons. In other words, where the space is limited, those crops should be raised which produce large quantities on small areas or which mature in a short time. Before making a plan of a garden, all of these matters should be considered.

The diagram of a garden should show the location of perennial crops, such as asparagus, rhubarb, and small fruits. These should be placed on one side or at one end of the area, so they will not be in the way when plowing and cultivating the garden. A garden diagram can be used as a record, showing the dates of planting and harvesting the various crops and also the area devoted to each vegetable. By keeping such a record mistakes made one year can be corrected the next. For example, if too much or too little of any vegetable was grown, reference to the diagram will show the extent of the space devoted to the crop and suggest the way to increase or reduce it. A diagram is valuable for the experienced gardener, but is most important for the beginner in gardening.

IMPORTANCE OF SUNLIGHT.

In making his plan the gardener should recognize that no amount of fertilizer, watering, and cultivation will make up for the absence of sunlight in a garden. Careful consideration should be given to how many hours a day any part of the yard is in the shadow of buildings, fences, or trees. If a successful garden is to be maintained, the greater portion of the plat must have at least five hours of sunlight a day. As a rule, foliage crops, such as lettuce, spinach, and kale, do fairly well in partial shade; but even these need sunshine for two or three hours a day. Plants which must ripen fruits, such as the tomato and eggplant, should have the sunniest locations.

SUCCESSION AND ROTATION OF CROPS.

In planning the location of crops consideration should be given to their succession and rotation in order to utilize the land to the best advantage and to check the ravages of diseases and insects. By a succession of crops is meant following one crop with another in the same season, while rotation means changing the crop on a given piece of land from season to season. In planning a succession attention should be given to utilizing the land all the time. As soon as one vegetable is mature another one should be planted in the same space. For example, early beans may be followed by cabbage; tomatoes by spinach, mustard, or turnips; early cabbage by fall potatoes or fall beans. When a crop is harvested early in the season and it is not practicable to plant another vegetable, the land should be planted to cowpeas or crimson clover, to be turned under to improve the soil.

Rotation of crops is as important in growing vegetables as in growing field crops, and the same principles can be applied. Crop rotation is important in checking diseases and insects and in keeping the soil in good condition. Where diseases are very severe, the same crop should not be planted continuously on the same area. Rotation of crops is one of the safeguards against soil infection.

Land upon which a diseased crop has been grown should not be used for the same or a closely related crop oftener than once in three years. It is usually advisable to rotate crops in such a way that foliage crops (such as cabbage, kale, spinach, and mustard) follow root crops (Irish potatoes, beets, parsnips, carrots, etc.) or those grown for fruits (tomatoes, peppers, melons, etc.). This can be accomplished in a measure by changing the location of crops in the planting plan or by reversing the plan from year to year.

AIDS TO EARLINESS.

In most sections of the South it is desirable to start plants of certain crops before it is safe to plant them out of doors. This can be done by planting seed in a box in the house or in a hotbed, or even in a coldframe.

THE SEED BOX.

The flat, or seed box (fig. 3), which is kept in the house, is perhaps the most practical device for use by the home gardener in starting early vegetables. By its use earlier crops of tomatoes, cabbage, cauliflower, Brussels sprouts, peppers, eggplant, and lettuce can be had with little outlay for equipment. Early potatoes sometimes are forced in the same way. Seeds so planted germinate and are ready for transplanting by the time it is safe to sow the same kind of seed in the open ground. When danger of frost is over and the soil is dry enough to work, the early garden may be started with seedlings well above the surface.

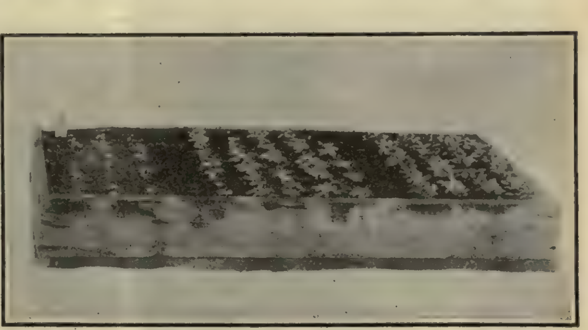
FIG. 3.—A flat, or seed box, used for starting plants in the house.

Any sort of wooden box filled with good soil answers the purpose, but the following specific suggestions for a flat of convenient size may be useful: Construct a box 3 to 4 inches deep, 12 to 14 inches wide, and 20 to 24 inches long. A layer of about 1 inch of gravel or cinders should be placed in the bottom, and it should then be filled nearly full with rich garden soil or soil enriched with decayed leaves or manure. The rich soil beneath the family woodpile or around decaying logs is excellent for this purpose. The soil should be pressed down firmly with a small piece of board and rows made one-fourth to one-half inch deep and 2 inches apart crosswise of the box. The seed should be sown thinly in rows and be covered. The soil should be watered and the box set in a warm place in the light. The best location is just inside a sunny window. Water enough must be given from time to time to cause the seeds to germinate and grow thriftily, but not enough to leak through the box. If a piece of glass is used to cover the box, it will retain the moisture in the soil and hasten the germination of the seeds. After the plants appear the box should be turned each day to prevent the plants drawing toward the light.

When the plants are from an inch to an inch and a half high they should be thinned to 1 or 2 inches apart in the row, so as to give them space enough to make a strong, stocky growth. If it is desired to keep the plants which are thinned out, they may be set 2 inches apart each way in boxes similar to the seed box. When the weather becomes mild the box of plants should be set out of doors part of the time, so that the plants will "harden off," in preparation for transplanting to the garden later. A good watering should be given just before the plants are taken out of the box for transplanting, so that a large ball of earth will stick to the roots of each one.

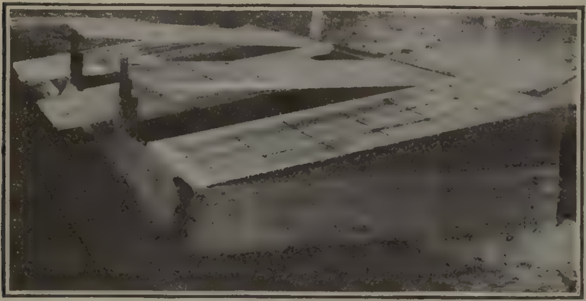

FIG. 4.—Hotbed used for starting plants early in the season in the upper South. Note the method of ventilation.

THE HOTBED.

A more satisfactory method of starting plants is by means of hotbeds or coldframes. A hotbed 6 feet by 6 feet in size will be large enough for the average garden and can be constructed rather cheaply. In the colder regions of the South some form of heat should be supplied. Fresh manure from the horse stable will be found satisfactory for this purpose. Turn the manure two or three times before placing it in the bed, in order to make it uniform in composition and mechanical condition. Make the excavation for the bed about 18 inches deep and put in 15 to 18 inches of fresh manure, packing it well by trampling. Arrange a frame, similar to the one shown in figure 4, over the manure, so the slope will be to the south. Place 4 or 5 inches of good garden loam over the manure and cover the frame with hotbed sash or a heavy canvas, preferably the former. The manure will heat quite rapidly for the first few days. During that time ventilate the bed frequently, to allow the gases to escape and to lower the temperature. The seeds should not be planted until the temperature goes down to 80° or 85° F. After the seeds have been planted, close attention should be given to the watering and ventilation of the bed. The soil should never be allowed to dry out, but it should not be kept water-soaked. Moisture is necessary for the germination of the seed and the growth of the plants, but an excess of moisture should be avoided, as it stimulates the development of diseases, especially damping-off. Water should be applied early enough in the day to allow the plants to dry before night. Ventilate the beds during the heated portion of the day, but cover them in time to insure their warming up enough to prevent the chilling of the plants during the night.

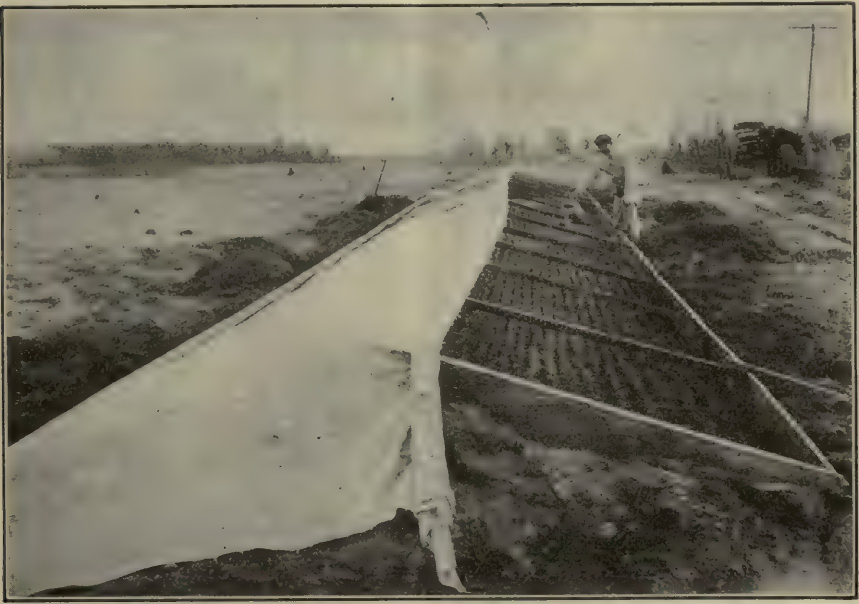

FIG. 5.—A large coldframe covered with canvas. This type of frame is often used for starting plants as well as for hardening them off.

THE COLDFRAME.

The coldframe (fig. 5), so useful in hardening plants started in the hotbed and for starting plants in mild climates, is constructed in much the same way as the hotbed, except that no manure is used and the frame may be covered either with glass sash or canvas. A coldframe may be built on the surface of the ground, but a more permanent structure suitable for holding plants over winter will require a pit 18 to 24 inches deep. The coldframe should be filled with a good potting soil. Plants should have more ventilation in a coldframe than in a hotbed, but should not receive so much water. It is best to keep the soil rather dry.

TRANSPLANTING.

In transplanting, remember that plants usually thrive better if put into ground that has been freshly cultivated. Transplanting to the open field is best done in cool, cloudy weather and in the afternoon. This prevents the sun's rays from causing the plants to lose too much moisture through evaporation.

For the best results, plants started in boxes, hotbeds, or coldframes should be transplanted when they reach a height of 1 to 2 inches. Transplanting tends to produce uniform, stocky plants, with a well-developed root system. The seedlings may be transplanted to boxes or to the hotbed or coldframe, to stand about 2 inches apart each way. Some growers transplant twice before setting in the open ground.

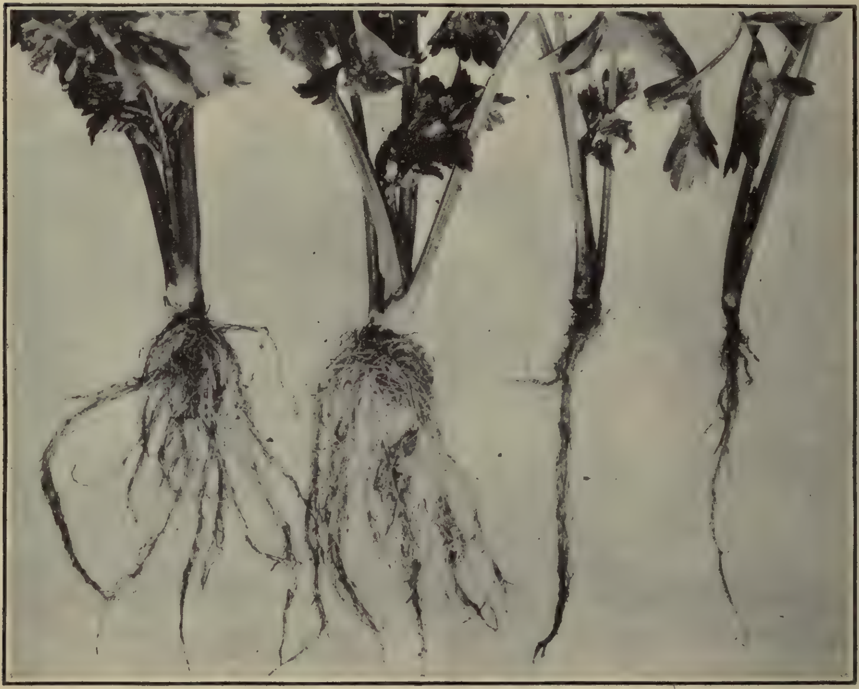

FIG. 6.—Celery plants, showing how transplanting stimulates root growth. The two plants on the left were transplanted; those on the right were not transplanted. All of these plants are from the same seeding.

Figure 6 shows four celery plants from the same seeding. The two at the left were transplanted, while those on the right were allowed to remain in the seed bed until time for planting in the garden.

HARDENING OFF.

Plants grown in a house, hotbed, or coldframe should be hardened off before they are transplanted to the garden. This can be accomplished by ventilation and exposure to outdoor conditions during the day in good weather. If the plants are in a hotbed or a coldframe the covers may be removed during the day when the weather is good and replaced toward nightfall. After danger of frosts is past the covers may be left off at night. By the time the plants are large enough to be transplanted to the garden they should be thoroughly accustomed to outdoor conditions. Such plants usually withstand the transfer to the garden with little check and few losses.

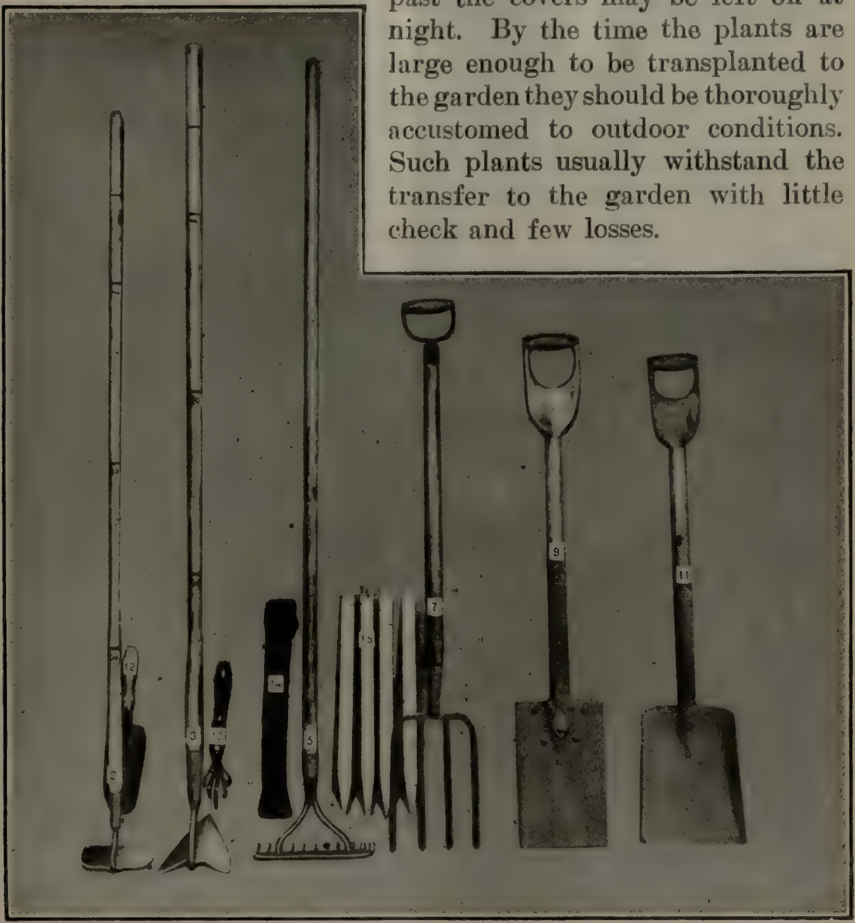

FIG. 7.—A set of useful garden tools: (2) Hoe, (3) heart-shaped furrow hoe, (5) steel-tooth rake, (7) spading fork, (9) spade, (11) shovel, (12) trowel, (13) scratch weeder, (14) garden line, (15) garden stakes or labels. Note that the hoe handles are marked off in feet and half feet for convenience in measuring.

SETTING PLANTS IN THE OPEN.

Before taking the plants from the bed they should be thoroughly watered and the water allowed to soak into the ground. This will insure a portion of the soil adhering to the roots and will prevent serious wilting or the checking of growth. Take up the plants with a trowel or spade, and pack them in boxes or baskets in which to carry them to the field.

The land should be in good condition and everything should be ready for quick operation when planting time arrives. Mark off the rows or dig the holes for the plants just before planting, to prevent the drying of the soil. If possible, set the plants on a cloudy day or just before nightfall. When the soil is very dry it is advisable to use a little water in the hole. The water should be applied when the hole is partially filled with soil, and the moist earth should then be covered with dry soil to prevent baking. Plants should be set a trifle deeper in the garden than they were in the plant bed. Pack the soil thoroughly around the plants, so as to avoid air spaces.

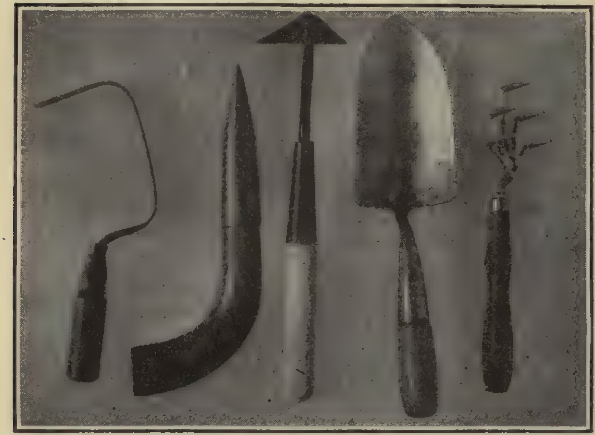

FIG. 8.—Small hand tools for the garden. From left to right they are a hand-scrape weeder, a dibble, onion weeder, trowel, and a scratch or claw weeder.

TOOLS FOR THE GARDEN.

In addition to the plows, harrows, and cultivators usually found on the farm, the gardener will find it convenient to possess additional implements and tools. Every farmer should have a common garden hoe, a steel-tooth rake, a spade, a trowel, and a spading fork. The other accessories shown in figures 7 and 8 will be found valuable but are not absolutely essential. A wheel hoe similar to the one shown in figure 9 is a desirable implement for any garden, as its use reduces the amount of hand hoeing necessary. In a city or town garden all the work is usually done with a wheel hoe and the hand tools shown in figures 7 and 8. The small hand weeders are especially useful in caring for the plants in hotbeds and coldframes, with a trowel is useful in taking up plants from the plant bed and setting them in the garden. The garden line is used in laying out the garden and in making the rows straight.

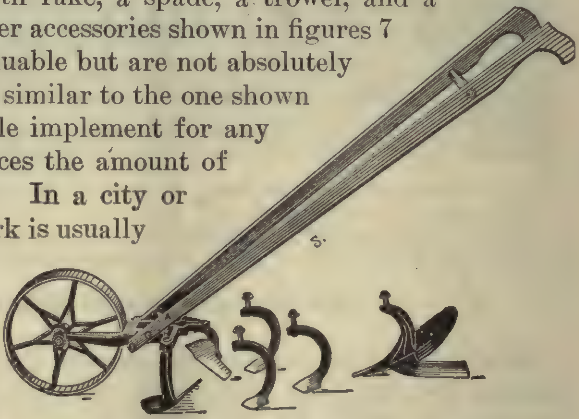

FIG. 9.—A wheel hoe, useful in any garden.

In addition to the tools and implements already mentioned, a wheelbarrow, a claw hoe, and a watering can will be found useful in gardening.

SEEDS FOR THE GARDEN.

The seeds for the garden should be at hand considerably in advance of the planting season. Secure catalogues from reliable seedsmen, and after making a plan of the garden select the varieties and quantities of each kind of seed needed.

The following are the approximate quantities of seed that should be purchased for a garden which is to supply vegetables for a family of four.

Seeds for a vegetable garden to supply a family of four.

Bean:	
Bush Lima	1 pint.
Pole Lima	1 pint.
Snap	1 to 2 quarts.
Beet	4 ounces.
Cabbage:	
Early	1 packet.
Late	One-half ounce.
Carrot	1 ounce.
Cauliflower	1 packet.
Celery	1 packet.
Corn, sweet	1 to 2 pints.
Cucumber	1 ounce.
Eggplant	1 packet.
Kale	2 ounces.
Lettuce	One-half ounce.
Melon:	
Muskmelon	1 ounce.
Melon—Continued.	
Watermelon	2 ounces.
Onion sets	4 to 6 quarts.
Pea, garden	4 to 6 quarts.
Parsley	1 packet.
Parsnip	One-half ounce.
Radish	1 ounce.
Salsify	1 ounce.
Spinach:	
In spring	One-quarter pound.
In fall	One-half pound.
Squash:	
Hubbard	1 ounce.
Summer	1 ounce.
Tomato:	
Early	1 packet.
Late	One-quarter ounce.
Turnip	2 to 3 ounces.

The quantities of seed specified should produce sufficient vegetables to supply the needs of the family during the growing season, as well as to supply a surplus for canning, drying, and storing.

It is not supposed that any family will desire to grow all of the vegetables listed, nor will all families require the same amount of any crop, but the estimates given will be a guide. For ordinary requirements the entire supply of seeds of snap beans, peas, beets, sweet corn, lettuce, radishes, and beets should not be planted at one time, but successive plantings should be made at intervals of two to four weeks, so that a fresh supply of vegetables may be had throughout the season.

PREPARATION OF THE SOIL.

If the land to be used for the garden has not been under cultivation, it should be cleared of all trees, underbrush, stumps, stones, and trash of all kinds. Where the soil has been used for gardening, all rubbish, including the remains of previous crops, should be removed and composted or burned. If disease has been serious during the preceding year, it is safer to burn the plant remains rather than to compost, though the composted material, even if diseased, might be applied to other portions of the farm where vegetables are not grown, without much chance of injuring the crops.

The soil that is to be used for vegetables should be thoroughly prepared before planting. A deep seed bed is desirable, and when an area that has never been plowed more than 4 inches deep must be used it should be deepened by gradually increasing the depth of plowing for a period of three or four years until the desired depth is attained.

Clay soil should be plowed in the fall if there is no danger of washing, so as to get it in a good mechanical condition before planting time. In the cooler regions of the South freezing will pulverize the soil, while in regions where freezes do not occur the pulverizing must be done by harrowing and cultivation. Sandy loams or soils that contain a large amount of humus should be plowed far enough in advance to allow the soil to settle before planting.

Thorough preparation by plowing, harrowing, and rolling or dragging will lessen the work of cultivation. It is not sufficient to smooth and level the surface; the pulverizing should extend down several inches.

Small gardens in cities and towns are usually prepared by hand rather than with horse-drawn implements. The work of breaking the soil is usually done with a spade, spading fork, or mattock. As the soil is turned up with the spade or fork it should be broken up by hitting it with the back of the tool used. Before the surface has a chance to bake it should be well pulverized with a rake.

IMPROVING THE TEXTURE OF THE SOIL.

It is desirable that the soil of the garden be as open and light as possible. Where a natural loam exists in the plat good texture can be obtained by digging and cultivating. Where the soil is heavy, containing much clay, however, other steps are necessary. If clean sand is available this may be mixed with the soil. Well-sifted coal ashes, which, unlike wood ashes, have no fertilizing value, are useful in lightening the soil. Care should be taken that no coarse cinders or pieces of partly burned coal are added to the soil with the ashes.

MANURES AND FERTILIZERS.

The soil for vegetable growing should be rich and well supplied with humus. Barnyard or stable manure is the best fertilizer, because it furnishes both plant food and humus. An application of

20 to 30 tons of manure to the acre is very satisfactory, and on some soils this application will need but little reinforcing with commercial fertilizers. The manure should be applied far enough in advance of planting time to allow it to decay. When coarse manure is used it should be applied in the fall and turned under, but well-rotted manure should be applied after plowing and should be well mixed with the soil by harrowing. On many soils it is advisable to apply commercial fertilizer, especially phosphates, in addition to the manure. An application of 300 to 600 pounds of acid phosphate to the acre will be sufficient. Sandy soils often need a little additional potash, which, under normal conditions, can be applied in the form of muriate or sulphate of potash at the rate of 200 to 400 pounds to the acre. An application of 100 pounds of nitrate of soda will give the plants a start in the spring before the nitrogen in the manure has become available.

Where manure is not available, some leguminous crop, such as cowpeas, soy beans, vetch, or crimson clover, should be turned under to supply humus and a part of the nitrogen. Additional fertilizing elements can be applied in the form of commercial fertilizers. No definite rule can be given for the kind or quantity of fertilizer to be applied, as this varies with the crop and soil. In most cases it is safe to apply 1,000 to 2,000 pounds of a high-grade fertilizer to the acre. One analyzing 2 to 4 per cent nitrogen, 8 per cent phosphoric acid, and 6 to 8 per cent potash should give good results if the soil is well supplied with humus. This fertilizer may be secured already prepared or may be mixed at home. The following combination will make a satisfactory fertilizer for a home garden and may be applied at the rate of 1,000 to 2,000 pounds to the acre. The quantities given are sufficient for an acre. They should be reduced proportionately for smaller gardens.

150 pounds of nitrate of soda.
650 pounds of cottonseed meal.
1,000 pounds of acid phosphate, 16 per cent.
200 pounds of muriate or sulphate of potash.

Under present conditions (January, 1918) potash is so scarce and expensive that most commercial brands of fertilizer contain no potash or only 1 to 2 per cent of this element; on most farms, however, wood ashes can be used to supply the needed potash for garden crops. Unleached wood ashes might be applied at the rate of 1,000 to 1,500 pounds per acre.

It should be borne in mind that commercial fertilizers will not produce satisfactory results unless the soil is well supplied with humus. In fact, large quantities of fertilizers are justified only where the soil is in good mechanical condition. Many soils in the South that have been in cultivation for a long time are in a poor mechanical condition and need humus, which can be supplied by turning under green crops or coarse manure.

PLANTING VEGETABLE SEEDS IN THE OPEN.

TIME FOR PLANTING EARLY CROPS.

No definite rule can be given as to the exact time that vegetable seeds can be safely planted in all sections, but the dates given in Tables I and II are approximately correct and may be followed with a reasonable degree of safety. The time given is based on the average date of the last killing frost in spring for the earliest planting and on the average date of the first killing frost in autumn for the latest planting. By reference to the maps shown in figures 10 and 11 one can readily determine the zone in which he is located. It should be remembered that there is a difference of about two weeks between zones in the dates for planting. It should also be borne in mind that the time recommended is based on the *average* dates of killing frosts. Some years a killing frost occurs later than the average in the spring and earlier than the average in the fall; however, it is advisable to take some chances on planting, in order to get crops as early as possible in spring and as late as possible in autumn.

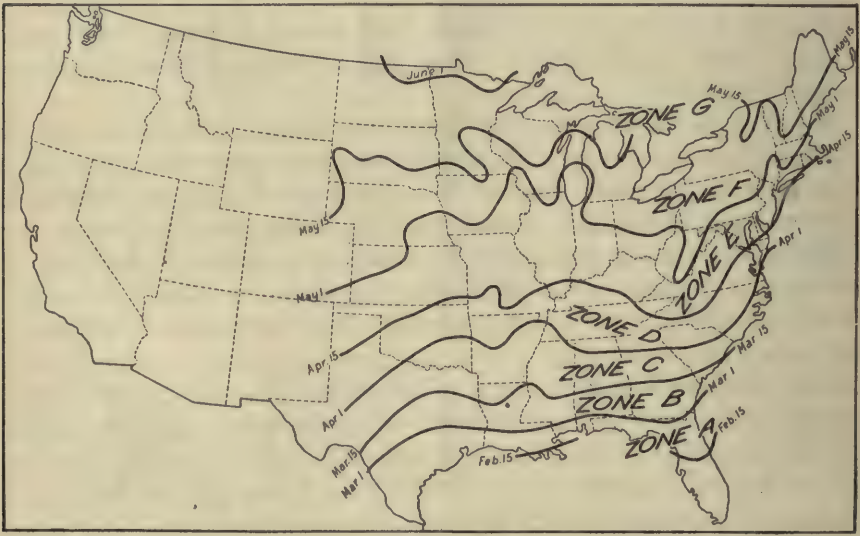

FIG. 10.—Outline map of the United States, showing zones based on the average date of the last killing frost in spring. The time of planting of the various vegetables in the different zones is determined by the dates given on this map.

In southern Florida below zone A, most vegetables are started in late summer and in autumn for winter and spring use. Some of the hardy crops can withstand the winter weather if they get a good growth in the autumn in zones B, C, and D. Cabbage, collards, turnips, spinach, and kale, for example, will withstand the winter even as far north as the upper part of zone D. Spinach, with a little covering of leaves, straw, or other litter, will sometimes go through the winter in zone E. Cabbage is planted in December in the vicinity of Charleston, S. C., but the plants used are well hardened by growing in the open. In most sections of zone B it is safer to plant cabbage from January 15 to February 15, especially if frame-grown plants are used. Very little time is saved by planting cabbage earlier than the dates given in the table, as those plants which pass through freezing weather are severely checked and stunted and, in addition, are more likely to go to seed than those which have not been checked.

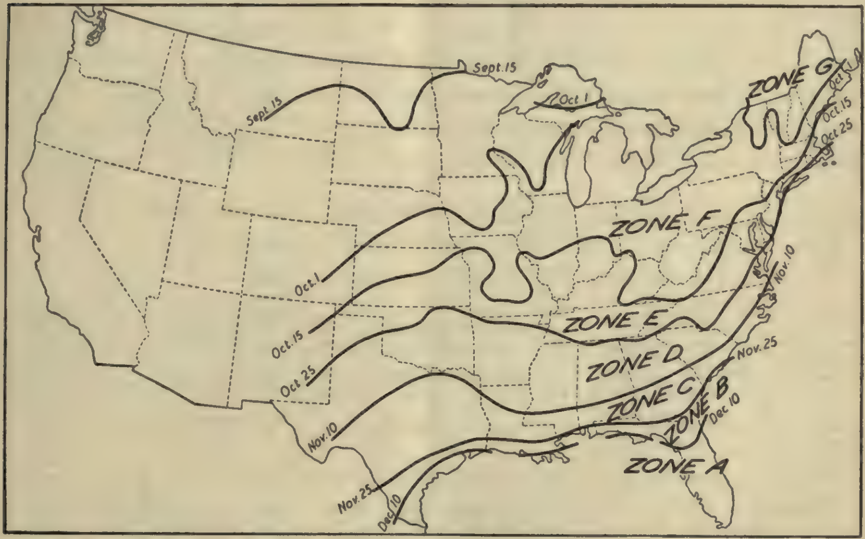

FIG. 11.—Outline map of the United States, showing zones based on the average date of the first killing frost in autumn. The latest safe dates of planting vegetables in the autumn are determined by the dates given on this map.

It should be borne in mind that the dates given in the table refer to the first planting. Several plantings should be made of crops which mature in a short time or which are in their prime only a short while. This is especially true of string beans, lettuce, radishes, peas, and sweet corn. Plantings of these should be made at intervals of two or three weeks until the weather gets too hot for their development.

TABLE I.—*Earliest safe dates for planting in the open in the zones of the United States illustrated in figure 10.*

Crop.	Zone A.	Zone B.	Zone C.	Zone D.	Zone E.
Asparagus	(Not grown).	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 15.	Apr. 15 to May 1.
Artichoke:					
Globe	Mar. 1 to 15.	Mar. 15 to Apr. 1	Apr. 1 to 15.	Apr. 15 to May 15.	May 1 to 30.
Jerusalem	Feb. 1 to 15.	Feb. 15 to May 1	Mar. 1 to 15.	Mar. 15 to Apr. 1	Apr. 1 to 15.
Bean:					
Lima	Mar. 1 to 15.	Mar. 15 to Apr. 1	Apr. 1 to 15.	May 1 to 15.	May 15 to June 1.
Snap	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to 30.	Apr. 1 to May 1	May 1 to 15.
Beet	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 15	Apr. 15 to May 1.
Brussels sprouts	do.	do.	do.	do.	Do.
Cabbage	Jan. 1 to Feb. 1.	Jan. 15 to Feb. 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 15.
Carrot	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 15.	Apr. 15 to May 1.
Cauliflower	do.	do.	do.	do.	Do.
Celery	do.	do.	do.	do.	Do.
Chard	do.	do.	do.	do.	Do.
Collard	Jan. 1 to Feb. 1.	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 15.
Corn, sweet	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 1	Apr. 1 to May 1	Apr. 15 to May 15.
Cucumber	Mar. 1 to 15.	Mar. 15 to Apr. 1	Apr. 1 to 15.	Apr. 15 to May 1	May 1 to June 1.
Eggplant	do.	do.	do.	do.	Do.
Garlic	Jan. 1 to Feb. 1.	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 15.
Kale	do.	do.	do.	do.	Do.
Kohl-rabi	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 1	Apr. 1 to May 1.
Lettuce:					
Head	do.	do.	do.	Mar. 15 to Apr. 15.	Do.
Leaf	Jan. 1 to Feb. 1.	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 15.
Melon	Mar. 1 to 15.	Mar. 15 to Apr. 1	Apr. 1 to 15.	Apr. 15 to May 1	May 1 to June 1.
Mustard	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 1	Apr. 1 to May 1.
Okra, or gumbo	Feb. 15 to Mar. 1	Mar. 15 to Apr. 1	Mar. 15 to 30.	Apr. 15 to May 1	May 1 to 15.
Onion:					
Seed	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 1	Apr. 1 to May 1.
Sets	Jan. 1 to Feb. 1.	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 15.
Parsley	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 1	Apr. 1 to May 1.
Parsnip	do.	do.	do.	do.	Do.
Pea:					
Smooth	Jan. 1 to Feb. 1.	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 15.
Wrinkled	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 1	Apr. 1 to May 1.
Peppers	Mar. 1 to 15.	Mar. 15 to Apr. 1	Apr. 1 to 15.	Apr. 15 to May 1	May 1 to June 1.
Potatoes:					
Irish	Jan. 1 to Feb. 1.	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 15.
Sweet	Mar. 1 to 15.	Mar. 15 to Apr. 1	Apr. 1 to 15.	Apr. 15 to May 1	May 1 to June 1.
Pumpkins	do.	do.	do.	do.	Do.
Radish	Jan. 1 to Feb. 1.	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 15.
Rhubarb	(Not grown).	(Not grown).	Mar. 1 to 15.	Mar. 15 to Apr. 15.	Apr. 15 to May 1.
Salsify	Feb. 1 to 15.	Feb. 15 to Mar. 1	do.	do.	Do.
Spinach	do.	do.	do.	do.	Do.
Squash	Mar. 1 to 15.	Mar. 15 to Apr. 1	Apr. 1 to 15.	Apr. 15 to May 1	May 1 to June 1.
Tomato	do.	do.	do.	do.	Do.
Turnip	Jan. 1 to Feb. 1.	Feb. 1 to 15.	Feb. 15 to Mar. 1	Mar. 1 to 15.	Mar. 15 to Apr. 15.

TIME OF PLANTING FOR THE FALL GARDEN.

In all sections of the South it is possible to have a good fall garden by starting the crops during late summer and early autumn. In zone A (fig. 11) most of the vegetables grown for fall and winter use are planted in late summer or early autumn.

In this region and in zone B most garden crops should be planted as soon as the hot weather will permit. It is difficult to get crops started during the hottest weather in zones B and C, but there is sufficient time to produce most of the common vegetables in the autumn by planting after the weather gets cool enough for the seeds to germinate and the plants to grow. In zone D practically all vegetables can be grown in the fall garden by starting the crops in late summer and early autumn, the time of planting depending on the length of time required for the crop to mature.

In zone E most crops must be started in summer in order to mature before frost, but short-season crops or hardy crops, such as lettuces, radishes, spinach, kale, mustard, and turnips, may be planted in August and September.

Table II shows the latest safe dates of planting for the vegetables that are commonly grown in the fall garden. Dates are not given for many crops in zone B because most long-season crops can not be planted early enough to produce a crop during the autumn, and short-season, hardy crops can be grown practically throughout the autumn and winter.

TABLE II.—*Latest safe dates for planting vegetables for the fall garden in the zones of the United States illustrated in figure 11.*

Crop.	Zone B.	Zone C.	Zone D.	Zone E.
Bean, snap	Oct. 1 to 15	Sept. 15 to 30	Aug. 15 to 30	Aug. 1 to 30.
Beet	do	do	Aug. 1 to 30	July 15 to Aug. 15.
Cabbage		Sept. 1 to 15	Aug. 15 to Sept. 1	Do.
Carrot		do	do	Do.
Cauliflower		do	Aug. 1 to Sept. 1	July 1 to Aug. 1.
Celery		Oct. 1 to 15	Sept. 1 to 30	Do.
Corn, sweet		Aug. 15 to 30	Aug. 1 to 15	July 15 to Aug. 15.
Cucumber		do	do	
Kale		Oct. 15 to Nov. 15	Oct. 1 to 30	Sept. 1 to 30.
Lettuce		do	Oct. 1 to 15	Do.
Mustard		do	do	Do.
Parsley		do	do	Do.
Pea		do	do	Aug. 15 to Sept. 15.
Potato:				
Irish		Aug. 15 to 30	Aug. 1 to 15	July 1 to 30.
Sweet	Aug. 15	Aug. 1 to 15	July 15 to 30	June 1 to 30.
Radish		Oct. 15 to 30	Oct. 1 to 15	Aug. 15 to Sept. 30.
Spinach		do	do	Do.
Tomato		Aug. 15 to 30	July 15 to Aug. 15	July 1 to 30.
Turnip		Oct. 15 to 30	Oct. 1 to 15	Aug. 15 to Sept. 30.

DEPTH OF PLANTING AND DISTANCE APART.

No general rule can be given with regard to the depth of planting that will fit all conditions, as different kinds of vegetables and different soils necessitate different practices. The smaller the seeds, the shallower the covering should be. In heavy clay soils the covering should be lighter than in sandy soils. When the soil is moist and cool, seeds of any given vegetable should be planted shallower than when the soil is dry.

Table III gives the proper depth of planting of the various vegetable seeds, as well as the quantity of seeds or number of plants required for 100 feet of row and the distance apart of the rows and the plants in the row.

TABLE III.—*Quantity of seeds and number of plants required for 100 feet of row, with the proper depths of planting and distances apart for rows and plants.*

Kind of vegetable.	Required for 100 feet of row.		Depth for planting seed.	Distance apart.		
	Seed.	Plants.		Rows.		Plants in the row.
				Horse cultivation.	Hand cultivation.	
			Inches.	*Feet.*		
Asparagus	1 ounce	60 to 80	1 to 1½	3 to 4	2 feet	15 inches.
Bean:						
Bush Lima	½ to 1 pint		1½ to 2	3	2½ feet	6 to 10 inches.
Pole Lima	½ pint		1½ to 2	4	3 feet	3 to 4 feet.
Snap	1 pint		1½ to 2	2½ to 3	2 feet	3 to 4 inches.
Beet	2 ounces		1 to 1½	2 to 2½	15 to 18 inches	4 to 5 inches.
Cabbage	½ ounce	65 to 90	½	2½ to 3	2 to 2½ feet	14 to 18 inches.
Carrot	1 ounce		½	2 to 2½	15 to 18 inches	3 to 4 inches.
Cauliflower	⅛ ounce	60 to 75	½	2½ to 3	2 to 2½ feet	15 to 18 inches.
Celery	do	200 to 250	⅛	3 to 4	18 to 24 inches	4 to 6 inches.
Collard	¼ ounce	65 to 100	½	2 to 2½	do	12 to 18 inches.
Corn, sweet	¼ pint		2	3 to 3½	2½ to 3 feet	10 to 12 inches.
Cucumber	½ ounce		1 to 1½	4 to 5	4 to 5 feet	15 inches.
Eggplant	¼ ounce	50 to 70	½	3	2 to 2½ feet	18 to 24 inches
Kale	½ ounce		½	2½ to 3	18 to 24 inches	8 to 10 inches.
Lettuce	do	125 to 200	½	2 to 2½	15 to 18 inches	6 to 10 inches.
Melon:						
Muskmelon	do		1 to 1½	5 to 6	5 to 6 feet	Drills 18 inches. Hills 5 feet.
Watermelon	1 ounce		1 to 2	8 to 10	8 to 10 feet	Drills 2 to 3 feet Hills 8 feet.
Okra	2 ounces		1 to 2	4	3 feet	2 feet.
Onion:						
Seed	1 ounce		½ to 1	2	15 inches	3 to 4 inches.
Sets	1 quart		1 to 2	2	do	Do.
Parsley	¼ ounce		⅛	2	do	Do.
Parsnip	½ ounce		½ to 1	2 to 2½	15 to 18 inches	Do.
Pea	1 to 2 pints		2 to 3	3 to 4	2½ to 3 feet	1 inch.
Potato:						
Irish	5 to 6 pounds		4	2½ to 3	2 to 2½ feet	12 to 18 inches.
Sweet	3 pounds	75 slips.	2 to 3	4 to 5	4 to 5 feet	14 to 18 inches
Radish	1 ounce		½ to 1	2	12 to 15 inches	1 inch.
Salsify	do		½ to 1	2	15 to 18 inches	Do.
Spinach	do		1 to 2	2	do	1 to 2 inches
Squash:						
Bush	½ ounce		1 to 2	3 to 4	3 to 4 feet	Drills 15 to 18 inches. Hills 4 feet.
Vine	do		1 to 2	7 to 10	7 to 10 feet	Drills 2 to 3 feet. Hills 8 feet.
Tomato	⅛ ounce	35 to 50	½ to 1	3 to 4	2 to 3 feet	2 to 3 feet.
Turnip	½ ounce		¼ to ½	2	15 to 18 inches	2 to 3 inches.

CULTIVATION OF GARDEN CROPS.

Frequent shallow cultivation should be given garden crops. By keeping the surface of the soil stirred a dust mulch is formed, which prevents the loss of moisture through the pores in the soil and keeps down weeds.

The soil should be cultivated as soon as possible after a rain, to break the crust and prevent baking. Sandy soils may be cultivated when quite wet, but clay soils should not be stirred when sticky. Too much emphasis can not be placed on the matter of thorough cultivation. If the work is properly done at the right time there will be little difficulty in controlling weeds.

In cultivating the garden, small-tooth cultivators should be used to prevent ridging or furrowing. Figure 12 shows a good type of horse cultivator for use in the garden. A turnplow or sweep should not be used for cultivation unless the land becomes so weedy that cultivators will not do the work. Frequent cultivation kills the weeds between the rows before they become large, but handwork will be necessary to keep the soil stirred between the plants and to keep down weeds in the row. A good hand cultivator, similar to the one shown in figure 9, is valuable to the vegetable gardener.

In a small garden, cultivation is done by hand, using a wheel hoe (like that shown in fig. 9), hand hoe, and rake.

The same principles of cultivation apply to the small garden cultivated by hand as apply to large gardens worked by means of horse implements.

IRRIGATION OF GARDEN CROPS.

Throughout those portions of the country where rains occur during the growing season it should not be necessary to irrigate in order to produce the ordinary garden crops. In arid regions, where irrigation must be depended upon for the production of crops, the system best adapted for use in that particular locality should be employed in the garden. Wherever irrigation is practiced the water should not be applied until needed, and then the soil should be thoroughly soaked. After irrigation, the land should be cultivated as soon as the surface becomes sufficiently dry, and no more water should be applied until the plants begin to show the need of additional moisture. Constant or excessive watering is very detrimental in every case. Apply the water at any time of the day that is most convenient and when the plants require it.

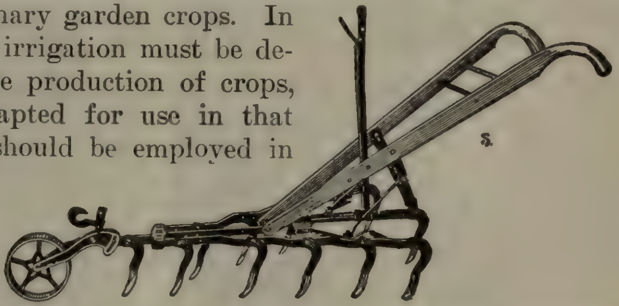

FIG. 12.—A small-tooth horse cultivator, useful in cultivating a small garden.

By the subirrigation method of watering, lines of farm draintiles or perforated pipes are laid on a level a few inches below the surface of the soil. This system is especially adapted for use in back-yard gardens where city water is available and the area under cultivation is small. Subirrigation is expensive to install, as the lines of tiles should be about 3 feet apart, or one line for each standard row. By connecting the tiles at one end by means of tiles across the rows the water may be discharged from a hose into the tiles at one point and will find its way to all parts of the system, entering the soil through the openings.

INSECTS AND DISEASES AFFECTING GARDEN CROPS.

In the control of insects and diseases that infest garden crops it is often possible to accomplish a great deal of good by careful management. In the autumn, after the crops have been harvested, or as fast as any crop is disposed of, any refuse that remains, if diseased or infested with insects, should be gathered and burned. Many garden insects find protection during the winter under boards and any loose material that may remain in the garden. Dead stems or leaves of plants are frequently covered with spores of diseases that affect those crops during the growing season, and these should be burned, as they possess very little fertilizing value.

This subject is treated in Farmers' Bulletin 856, entitled "Control of Diseases and Insect Enemies of the Home Vegetable Garden," to which reference should be made for detailed suggestions for the control of insects and diseases affecting vegetables.

THE STORAGE OF VEGETABLES FROM THE GARDEN.

It is as important to store the surplus vegetables properly as to grow them. The successful storage of vegetables is not at all difficult; in fact, good storage facilities already exist in most homes, it being only necessary to make use of the cellar, the attic, a large closet, or some other part of the dwelling, depending upon the character of the product to be stored. A cool well-ventilated cellar under the dwelling offers good conditions for the storage of such vegetables as potatoes, carrots, beets, and other root crops. If such a cellar is not available, it is often possible to store in banks or pits or in outdoor cellars. For full information on the storage of vegetables, see Farmers' Bulletin 879, entitled "Home Storage of Vegetables."

CULTURAL SUGGESTIONS FOR SPECIFIC CROPS.

ARTICHOKE, GLOBE OR FRENCH.

The French or globe artichoke is grown commercially in California and in some of the Southern States. It is grown for home use to some extent in nearly all sections of the United States except in the very coldest portions. When grown in the North it is necessary to protect the crown in winter, to prevent injury by freezing. The plants are usually propagated from suckers, or offshoots, taken from older plants. Seeds are sometimes used, but the seedlings do not come true to the variety and the seedling plants often bear heads of inferior quality. When seeds are used for propagating the plant, they should be sown in a well-prepared seed bed, preferably in a hotbed or coldframe. When the young plants reach a height of 5 or 6 inches they should be set in the field or garden. The plants usually do not bear heads until the second year, but in California when the plants are set in April some heads are gathered the first season. The plants will continue to head for several years if they are not allowed to produce too many suckers. As a rule, the planting is renewed every four or five years.

The globe artichoke requires a deep, rich soil for its best development. If grown on poor soil the heads will not be tender and palatable. Barnyard manure is the best fertilizer for this crop, although commercial fertilizers can be used to advantage where the soil contains considerable humus. Many growers apply 20 to 25 tons of manure to the acre each year. Where commercial fertilizer is relied upon, an application of 1,000 to 1,500 pounds of high-grade material can be used to advantage. Clean cultivation should be given throughout the growing season. Hand hoeing between the plants in the row is necessary, especially when the plants are small.

The heads should be cut from the plant when the scales are still tender and form a compact globe. If the heads are allowed to remain on the plant too long, they become tough and woody. The heads are prepared for the table in many ways, the most common of which is to boil in salted water until tender and serve whole. They are eaten by pulling off the scales with the fingers, then dipping the base of the scale in drawn butter and removing the fleshy part by drawing it between the teeth. Artichokes, when the heads are tender, are sometimes served raw as a salad and are used in many other ways.

There is a limited demand for globe artichoke heads in most of our markets, but they must be of good size, tender, and free from spines. The heads are graded according to size and packed for shipment to distant markets in tight drums. For local markets the heads are usually packed in open boxes or baskets.

ARTICHOKE, JERUSALEM.

The Jerusalem artichoke will grow in any good garden soil and should be planted 3 to 4 feet apart each way, with three or four small tubers in a hill. If large tubers are used for planting, they should be cut the same as Irish potatoes. Plant as soon as the ground becomes warm in the spring and cultivate as for corn. A pint of tubers cut to eyes will plant about 30 hills. The tubers will be ready for use in October, but may remain in the ground and be dug at any time during the winter.

The tubers are prepared by boiling until soft and are served with butter or creamed. They are also used for salads and pickles.

The Jerusalem artichoke is not of great importance as a garden vegetable, and the plant has a tendency to become a weed.

ASPARAGUS.

Asparagus should be grown in every home garden where it will thrive, because it is one of the earliest vegetables and is a valuable addition to the spring diet. The soil for asparagus should be made quite rich by the application of partly rotted manure before the plants are set. As soon as danger from hard frosts is over, the seeds of asparagus may be sown in the rows where the plants are to remain. Soaking the seed in hot water for an hour or two before planting will hasten germination. The seedlings should be thinned to stand 15 inches apart in the row.

Quicker results can be secured, however, by buying roots from some seedsman or dealer. The roots may be planted in the autumn or early spring. Before setting the plants, the soil should be loosened deeply by spading or with a subsoil plow. When horse cultivation is to be used, set the plants 15 inches apart in rows 3½ to 4 feet apart. When hand cultivation is to be used, the roots may be set in a solid bed 1 foot apart each way. Cover the roots to the depth of 4 or 5 inches. The bed should receive a dressing of manure or fertilizer each year, preferably in the autumn.

No shoots should be removed the first year the plants are set in the permanent bed, and the cutting season should be short the second year. After the bed is well established, with proper care and fertilizing it should last indefinitely. During the cutting season, all of the shoots, even those too small for use, should be removed. After this, the tops should be allowed to grow until late in the season, when they should be removed and burned and the soil between the rows cultivated. Apply a dressing of manure after cultivation, and allow the manure to remain on the bed.

Varieties recommended: Palmetto, Reading Giant, and Giant Argenteuil.

For further information, read Farmer's Bulletin No. 829, entitled "Asparagus."

BEANS.

Beans will not withstand much cold, so they should not be planted until danger of frost is past and the ground begins to warm up. The first planting should be made as soon as the ground is reasonably warm, and other plantings may be made at intervals of ten days or two weeks until hot weather sets in. Beans for the fall garden should be planted in late summer, and successive plantings may be made at the intervals suggested until about eight weeks before time for the first frost in the autumn.

Bush beans should be planted to stand 3 or 4 inches apart in rows 30 inches apart where horse cultivation is to be used. For hand cultivation, 20 to 24 inches between the rows will be satisfactory. Among the best varieties of bush beans are the Stringless Green Pod, Refugee, Hodson's Kidney Wax, Currie's Rustproof Wax, and Wardwell's Kidney Wax.

Lima beans, both pole and bush, should be grown in the garden. These should be planted after all danger of frost is over and the soil is warm. Plant the pole beans 8 to 10 seeds in a hill and thin to 3 or 4 after the plants become established. The hills should be 4 or 5 feet apart. For bush Lima beans, plant 5 or 6 inches apart in rows 30 to 36 inches apart.

When planting beans of any kind the seed should not be covered over 2 inches, and on heavy soils they should not be covered more than 1¼ to 1½ inches.

Varieties recommended: Seibert's Pole Lima, Carpinteria Lima, and King of the Limas are good varieties of pole Lima beans, and Landreth's Bush Lima, Dreer's Bush Lima, and Henderson's Bush Lima are good varieties of the bush type.

For further information on bean growing, read Farmers' Bulletin 289, entitled "Beans."

BEETS.

Beets can be planted as soon as danger of frost has passed, even before the ground has become warm. Sow the seeds in drills 14 to 18 inches apart, if to be hand cultivated, covering to the depth of about 1 inch. As soon as the plants are well up, thin them to stand 3 to 4 inches apart. Make two or three plantings, so as to have a continuous supply of young, tender beets throughout the season. In many sections of the South beets may be left in the ground through the winter, to be pulled when wanted.

Varieties recommended: Crosby's Egyptian, Bassano, Early Eclipse, and Early Blood Turnip.

BORECOLE. See KALE.

BRUSSELS SPROUTS.

Brussels sprouts are closely related to cabbage and cauliflower, and may be grown in the same manner. Instead of a single head, Brussels sprouts form a large number of small heads in the axils of the leaves (fig. 13).

As the head begins to crowd, the leaves should be broken from the stem of the plant, to give them more room. A few leaves should be left at the top of the stem where the new heads are being formed. Brussels sprouts are more hardy than cabbage, and in mild climates may remain in the open ground all winter, the heads being removed as desired. For winter use in cold localities, take up plants that are well laden with heads and set them close together in a pit, coldframe, or cellar, with a little soil around the roots. The uses of Brussels sprouts are similar to those of cabbage, but they are considered to be of a superior flavor.

CABBAGE.

In Florida and the Gulf coast region of the other Southern States cabbage seed may be sown in the open any time from September to January. Along the Atlantic coast, from Charleston, S. C., to Florida, seed may be sown in the open in October. In all other sections of the South hotbeds or coldframes should be used for starting the plants. A canvas-covered frame will be satisfactory except in the colder regions of the South, where hotbeds should be used. The seed should be planted in the frames in November or December, or about eight weeks before time for planting in the open. Cabbage will withstand a hard freeze if the plants have been hardened off before they are planted in the field.

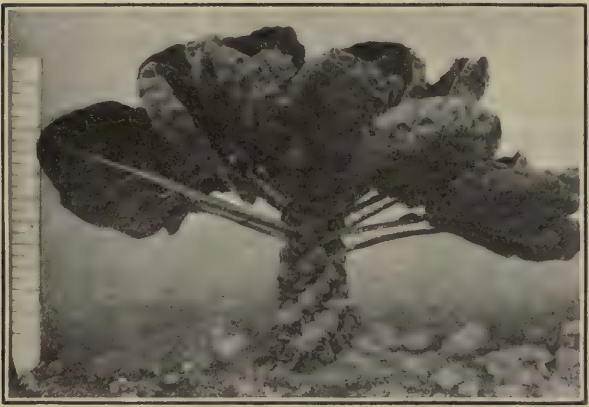

FIG. 13.—A single plant of Brussels sprouts. The small "heads" on the stalks are cut off and cooked like cabbage.

For spring and early-summer cabbage the following varieties are recommended: Jersey Wakefield, Charleston Wakefield, Allhead Early, and Succession. The Copenhagen Market, a new variety, has given excellent results in many localities and is well worthy of a trial.

In most sections of the South it is not advisable to grow cabbage during midsummer, but a fall crop should be grown. The same varieties may be grown in the autumn as in the spring, but it is usually desirable to plant larger varieties, such as Flat Dutch or Danish Ball Head. Seed for the fall crop should be planted in a cool location in late summer and the plants set out as soon as they reach the proper size and the soil contains sufficient moisture to start growth. Cabbage plants should be set 14 to 18 inches apart in rows 30 to 36 inches apart. The earlier varieties, which grow small heads, are usually set closer than the later ones.

For further information on cabbage growing, read Farmers' Bulletin 433, entitled "Cabbage."

CABBAGE, CHINESE.

This plant is said by botanists to be very closely related to the turnip. It makes a head of erect leaves, with no stem, the head (fig. 14) resting directly on the ground. It is often listed by seedsmen as Pai T'sai, or Pe-tsai, which is one form of its Chinese name. The plant may be used as a potherb, like kale or spinach, or, when headed, makes a very fine salad plant, being more tender when cut up for slaw than the ordinary cabbage. It is difficult to get it to head in the spring, especially in the South, so that the spring crop is usable only as greens. For the fall crop it should be planted at the same time as fall turnips, as it matures in much less time than ordinary cabbage.

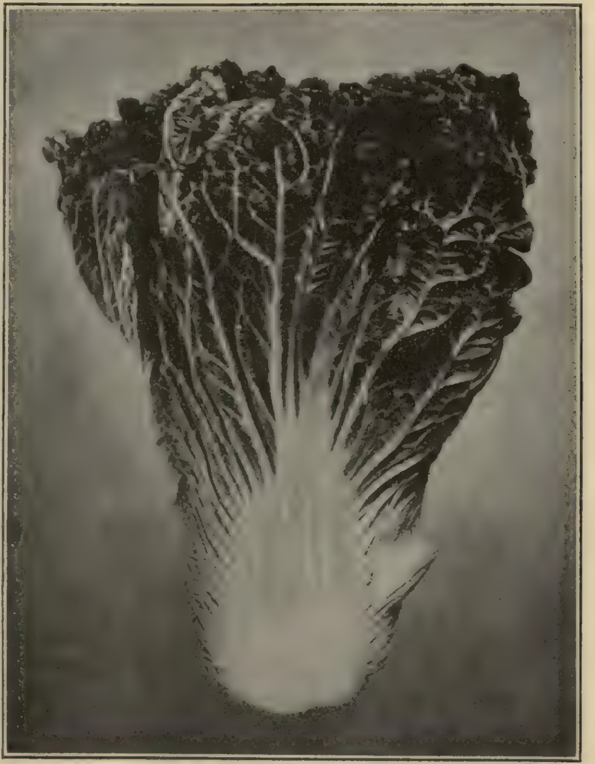

FIG. 14.—A trimmed head of Chinese cabbage ready for use.

The Chinise cabbage demands very rich, well-drained soil, but must not be allowed to suffer from lack of moisture. Seed should be started in a seed bed, and the plants should be transplanted when they are quite small. They should be set not closer than 2 feet apart each way, and will well repay careful and continuous cultivation.

CARROT.

The soil and cultural requirements of carrots are practically the same as for beets. Carrot seed, however, should not be planted so deep as beet seed, and the plants can be allowed to grow closer together in the row. Carrots may be dug in the autumn and stored in banks or cellars, or they may be left in the ground to be harvested as needed.

Varieties recommended: Half-Long Scarlet, Early Scarlet Horn, and Chantenay.

CAULIFLOWER.

Cauliflower thrives best on a rich, moist soil. The culture of this crop is about the same as for cabbage, but it will not withstand as much frost. In order to secure bleached heads it is necessary to protect them from the sun. The usual practice is to tie the leaves together over the heads.

Cauliflower is often prepared for the table in the same way as cabbage. One of the best methods of preparing cauliflower is to boil the whole head in salt water (1 teaspoonful of salt to 1 quart of water) until it is tender. Drain off the water, place the cauliflower in a baking dish, and pour over it a white sauce made as follows: Melt 2 tablespoonfuls of butter and rub into it 2 tablespoonfuls of flour; add 1 cup of cold milk; stir until smooth; boil the milk with the flour; and butter until thick. Pour the white sauce over the cauliflower, sprinkle with 2 tablespoonfuls each of grated cheese and buttered crumbs, and brown in an oven.

Varieties recommended: Early Snowball and Dwarf Erfurt are the varieties of cauliflower most commonly grown in the South.

CELERY.

In the lower South celery is grown as a fall or winter crop, as it will not mature during hot weather. The seed is sown in a cool, shady place in late summer and the plants set out in the autumn as soon as the soil becomes moist. The seed should be sown in rows and covered lightly (not more than one-eighth of an inch) or sown broadcast and covered with burlap, straw, or some other material, to prevent the loss of moisture while the seed is germinating. It will be necessary to water the seed bed often during dry weather.

In the upper South celery may be grown in the spring or in the autumn. As a spring crop, the seed should be started in a hotbed during the winter, so that the plants may mature before midsummer. Celery does not bleach well in hot weather, but rots when banked or boarded for bleaching.

Set the celery plants 6 inches apart in rows 3 feet apart for horse cultivation or 18 to 24 inches apart when hand cultivation is to be employed.

Celery requires a deep, rich, moist soil and frequent shallow cultivation. When grown as a fall crop celery may be planted after some other crop, such as peas, beans, cabbage, lettuce, or radishes. When the celery plants are nearly grown a little soil should be drawn around the base to hold the plants in place. About two weeks before they are wanted for the table the bleaching should begin. Soil, boards, or paper may be used for bleaching, but soil should be employed only when the weather is cool. When soil is to be used for bleaching, the rows should be 4 feet apart. Some quick-maturing crop can be grown between the rows of celery to make use of the space up to the time for bleaching.

Varieties recommended: Golden Self-Blanching, Columbia, and Giant Pascal.

For further information on celery growing, read Farmers' Bulletin 282, entitled "Celery."

CHARD.

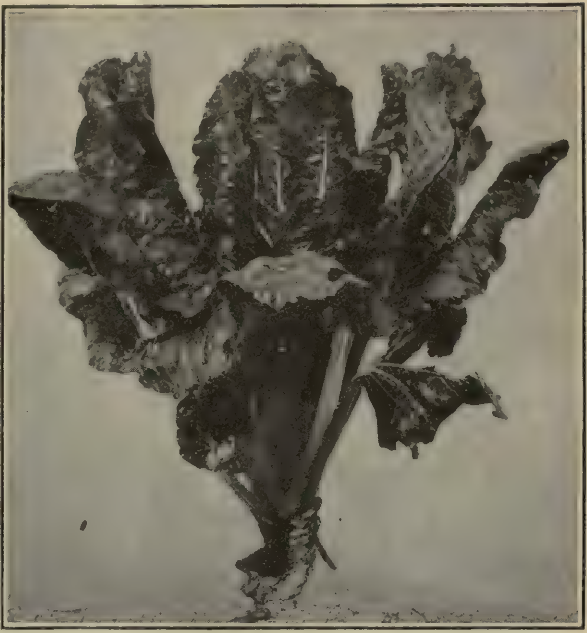

FIG. 15.—A single plant of chard, showing leaves ready for use.

Chard, or Swiss chard, is a beet which is grown for its foliage instead of its root (fig. 15). The leaves are cooked and used in very much the same way as spinach, as a potherb or green. The thickened leaf stem is sometimes cooked and used very much like asparagus. One of the good points about this vegetable is that crop after crop of leaves may be cut without injuring the plant.

Chard is planted about the same time and in the same manner as beets, but as the top grows larger it should be given more space than the garden beet.

COLLARDS.

A group of nonheading cabbages differing slightly from kale, but withstanding summer heat better than either kale or cabbage, is extensively grown throughout the South under the name of Georgia collards. Collards do not make a true head, but form a rosette of leaves, which are very tender. The culture and uses of this plant are the same as those of cabbage and kale.

CORN, SWEET.

Sweet corn should be planted on rich land and cultivated the same as field corn. Plant the seed as soon as the soil is warm in the spring, and make successive plantings every two or three weeks until late summer. The same results can be obtained to some extent by planting early, medium, and late varieties. Plant the seeds about 2 inches deep in drills 3 feet apart, and thin to a single stalk every 10 to 14 inches.

Sweet corn, when grown in the South, passes so quickly from the milk to the dough stage that care should be exercised to gather the crop just at the right time, in order to secure the most satisfactory results. The flavor of sweet corn depends upon the stage of maturity and the method of handling the product from the plant to the table. Sweet corn loses its sugar content very rapidly after being removed from the stalk. It should, therefore, be picked only a few hours, and preferably a few minutes, in advance of the time when it is to be placed in the pot.

Varieties recommended: For early corn Golden Bantam and Adams Early are suggested, and for medium and late varieties Black Mexican or White Mexican, Country Gentleman, and Stowell's Evergreen. The last-named variety has the largest ears and is the most productive.

CUCUMBERS.

The soil for cucumbers should be rich, and it is a good plan to apply well-rotted manure under the rows or hills. If planted in rows, open the furrow and scatter the manure along the furrow, turning fresh soil over the manure before planting the seeds. If the seeds are planted in hills, confine the application of manure to the area occupied by the hills.

As cucumbers are easily injured by cold, it is not advisable to tlant until all danger of frost is over and the ground has begun to warm up. For very early cucumbers the seeds should be planted in a hotbed in old strawberry boxes or plant bands or directly in the soil of the bed. By starting the plants in hotbeds the cucumbers will be ready for the table two or three weeks earlier than if started in the open. For the main crop, drill the seed in rows 5 feet apart, and after the plants reach a height of 3 or 4 inches thin them to stand 12 to 18 inches apart in the row, or plant the seeds in hills 4 feet apart each way and thin to two or three plants to the hill.

Cucumbers should be given frequent shallow cultivation until the vines fill most of the space between the rows; after this very little attention will be needed except to pull out any weeds by hand. Do not allow any fruit to ripen on the vines until the end of the picking season, as new fruits will not form while older ones are ripening.

Young cucumber plants are often destroyed by the cucumber beetle. It is possible to protect the plants by covering them with small wooden frames over which mosquito netting has been stretched. Air-slaked lime sprinkled over the small plants is an added protection against the cucumber beetle.

Varieties recommended: White Spine, Davis Perfect, and Emerald.

For further information on cucumber growing, read Farmers' Bulletin 254, entitled "Cucumbers."

EGGPLANT.

The plants for this crop should be started in a hotbed or in a box in the house about two months before time for planting in the field. They should not be set in the field until after all danger of frost has passed and the ground has become quite warm. Set the plants 18 to 24 inches apart in rows 3 feet apart, and give clean, shallow cultivation to keep the plants growing rapidly. A dozen good, healthy plants will supply enough fruit for the average-sized family throughout the season, as they are prolific when well grown (see fig. 16).

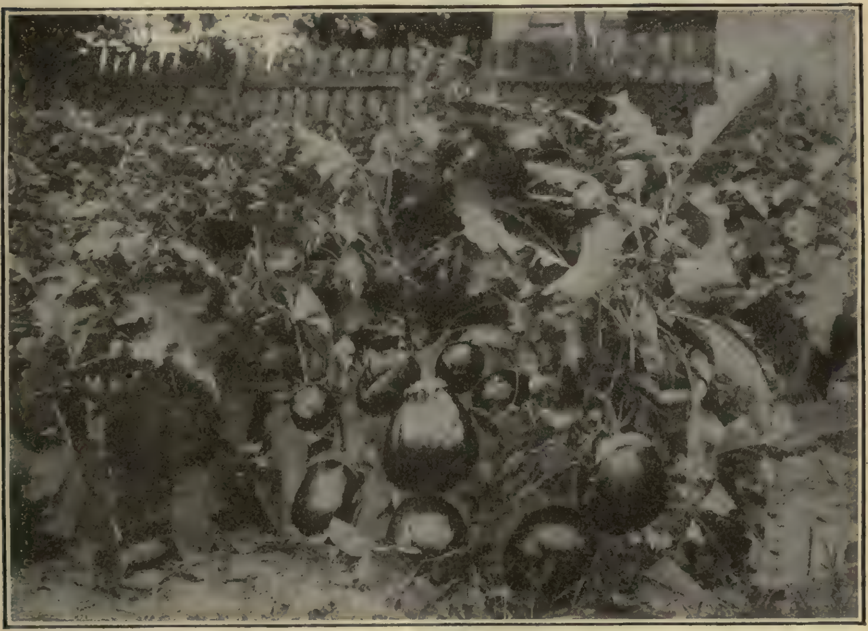

FIG. 16.—The eggplant, when grown under good cultural conditions, as shown in this illustration, is a prolific yielder. All the fruits shown here are on a single plant.

Eggplant may be used in several ways, one of which is the following: Peel and cut into slices one-fourth to one-half inch thick and soak in salt water for an hour; boil until tender; then coat with cracker crumbs or flour and fry in butter or fat. Another method is to steam or bake the eggplant whole, the pulp being eaten from the shell with salt, pepper, and butter.

Varieties recommended: New York Improved Purple, Black Beauty, and Florida High Bush.

GARLIC.

Garlic is propagated by separating the bulbs into the small bulblets, or cloves, and planting these separately in rows 12 to 14 inches apart and from 3 to 4 inches apart in the row, either in the autumn or spring. In other respects the cultivation is the same as for onions. The mature bulbs are pulled and left on the ground until the tops are dry, when they are gathered, braided together, and hung in a shed to cure. Garlic is used for flavoring purposes.

HORSE-RADISH.

Horse-radish can be grown in the cooler portions of the South, but does not thrive in the lower South. It does best in a deep, rich soil where there is plenty of moisture. The rows should be 3 feet apart and the plants 12 to 18 inches apart in the row. Tops cut from large roots or pieces of small roots are used for planting. A comparatively few hills of horse-radish will be sufficient for family use, and the roots required for starting can be secured of seedsmen for 25 or 30 cents a dozen. This crop will require no particular cultivation except to keep down the weeds and is inclined to become a weed itself if not controlled.

The large fleshy roots are prepared for use by peeling and grating. The grated root is treated with a little salt and vinegar and served as a relish with meats, oysters, etc. The roots should be dug during the winter or early spring before the leaves start. After being treated with salt and vinegar the grated root may be bottled for summer use.

KALE.

Kale is a very hardy crop and can be grown in the open during the autumn and winter in practically all sections of the South. Sow the seed early in the autumn, in drills 18 inches apart for hand cultivation and 30 inches apart for horse cultivation. Thin the plants to stand 4 to 6 inches apart in the row. A spring crop of kale should be planted to furnish fresh, tender greens after the winter kale has become tough. Seed for the spring crop may be sown as soon as the soil can be conveniently worked.

Varieties recommended: Dwarf Curled, Tall Scotch, and Siberian.

KOHL-RABI.

Kohl-rabi belongs to the same class as cabbage and cauliflower, but does not resemble either. The edible portion is the swollen stem, which resembles a turnip, but which is formed above ground, as shown in figure 17. Kohl-rabi should be grown both in the spring and in the autumn. Sow the seed in drills and thin the plants to 6 inches apart in the row. The rows should be 18 inches apart for hand cultivation and 30 to 36 inches apart for horse cultivation. The fleshy stems should be used while fresh and tender, as they become tough and stringy with age.

Variety recommended: White Vienna.

LETTUCE.

Lettuce thrives best during cool weather, so it should be planted in the spring and autumn. In order that the leaves or head may be crisp, the crop should be forced and successive plantings made ten days or two weeks apart. In the lower South lettuce can be grown in the open and in the upper South in hotbeds or coldframes throughout the winter.

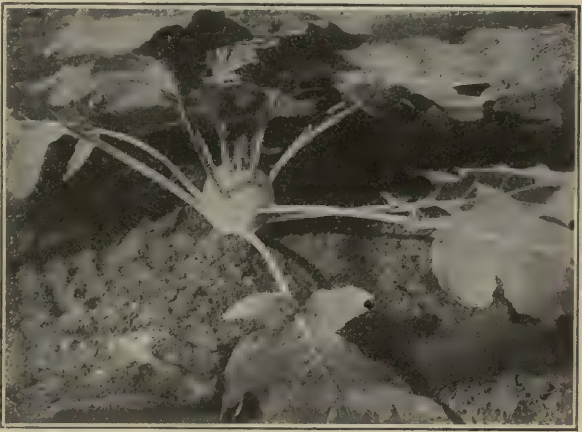

FIG. 17.—Kohl-rabi, showing the swollen stem, which grows above ground.

When grown in the garden the seeds should be sown in rows 14 to 16 inches apart and the plants thinned to the desired distance. The heading type should be thinned to stand 8 inches apart in the row, but with the loose-leaf type the plants may be grown close together and thinned as needed for the table. For a very early crop, start the plants in a hotbed or coldframe and transplant the young plants to the garden as soon as hard freezes are over.

Lettuce planted in the autumn may be left in the ground over winter in many sections of the South. Give the plants frequent shallow cultivation with hand tools.

Varieties recommended: Grand Rapids or Black-Seeded Simpson for loose-leaf lettuce, and Big Boston, Hanson, and California Cream Butter for head lettuce. Figure 18 shows a good type of head lettuce.

MELONS.

Muskmelon.—The culture of the muskmelon is the same as for the cucumber except that the plants are usually given more space. Plant 8 to 10 seeds in a hill, spacing the hills 6 feet apart each way. After the plants become established, thin out all but four of the best ones. Another method is to sow in drills 6 feet apart and thin to single plants 18 to 24 inches apart.

Varieties recommended: Rocky Ford, Netted Gem, Emerald Gem, Eden Gem, Jenny Lind, and Paul Rose.

Watermelon.—The cultivation of the watermelon is the same as for the cucumber and muskmelon, except that the plants require more space. Plant watermelon seed in rows 8 to 10 feet apart and thin to single plants 3 feet apart, or plant in hills 8 to 10 feet apart each way.

Varieties recommended: Kleckley Sweets, Florida Favorite, Georgia Rattlesnake, and Tom Watson.

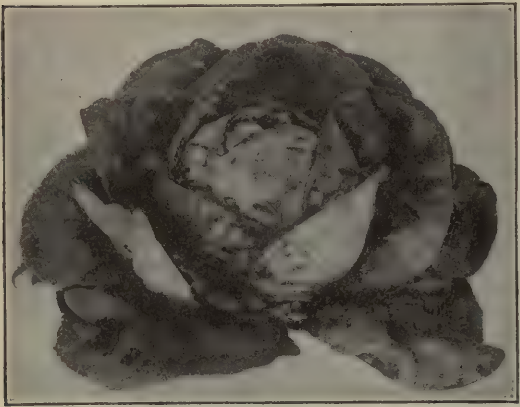

FIG. 18.—Head lettuce, which produces very tender, almost white leaves in the center of the head, but is harder to grow than the loose-leaf types.

MUSTARD.

Mustard is used largely for greens and can be grown in early spring and late autumn. The seeds for the spring crop should be sown as soon as the soil can be put into condition. For the fall crop, sow the seeds in late summer or early autumn in drills about 1 foot apart. As the plants require but a short time in which to reach edible maturity, frequent sowings should be made.

Varieties recommended: Giant Ostrich Plume and Large-Leaved Curled.

OKRA, OR GUMBO.

Sow seeds of okra in the open after danger of frost is over and the soil becomes quite warm. The rows should be 3 to 4 feet apart for dwarf varieties and 4 to 5 feet for the tall kinds. Sow the seed a few inches apart in the row and thin the plants to 18 inches to 2 feet apart. Give frequent shallow cultivation until the plants are nearly grown.

The pods are the part of the plant used for food and should be gathered while still crisp and tender. If the pods are removed so as to allow none to ripen, the plants will continue to bear until killed by frost.

Varieties recommended: White Velvet, Dwarf Green Prolific, Perkins Mammoth, Long Podded, and Lady Finger.

For further information on okra, read Farmers' Bulletin 232, entitled "Okra: Its Culture and Uses."

ONIONS.

For very early bunch onions it is the common practice to plant sets in drills 12 to 14 inches apart and 2 to 3 inches apart in the row. The sets may be put out in the autumn or as early in the spring as the land can be prepared. In the cooler regions of the South the sets will need some protection if planted in the fall, and hay or straw may be used to keep them from freezing.

For dry onions, sow the seed thickly in drills about 12 to 14 inches apart in the spring as soon as danger from hard frosts is over. For early bulbs the seed may be planted in a hotbed or coldframe and the young plants transplanted to the open when conditions are favorable. Plants 4 or 5 inches high are of good size for transplanting.

Onions require frequent shallow cultivation, and it may be necessary to resort to hand weeding. When the tops begin to die and the bulbs are full grown, the onions should be pulled and left in the field for a few days to dry. Then the tops should be clipped off and the bulbs placed in crates or bags and stored in a well-ventilated place to cure.

Early green onions may also be produced from the Multiplier or Potato varieties planted in the autumn. The large bulbs of these onions contain a number of "hearts," or buds, and if planted will produce a number of marketable onions and a bunch of "sets." The small sets have but one "heart" and will produce large bulbs the next year. A few large bulbs should be planted each year to produce sets for fall planting.

The Top, or Tree, onion produces a number of bulblets on top of the stem. These small bulbs can be planted in the autumn and will produce onions the following spring.

Varieties recommended: Southport White Globe, Southport Red Globe, Southport Yellow Globe, Danvers, Red Wethersfield, Australian Brown, and Prize Taker. In some sections of the South the Creole is grown and the Louisiana, or Red Creole, is a popular variety. The Bermuda is a good type of mild-flavored onion and is desired by many. The important varieties of Bermuda onions are the Crystal Wax, White Bermuda, and Red Bermuda.

For additional information on onion growing, read Farmers' Bulletin 354, entitled "Onion Culture."

OYSTER PLANT. See SALSIFY.

PARSLEY.

Parsley is used mainly for garnishing meats, but can be used for flavoring soups and other foods. Sow parsley seed thickly in a drill, or sow broadcast and cover lightly either in the autumn or early spring. A space a yard square will be sufficient for parsley.

Varieties recommended: Plain Leaved and Double Curled.

PARSNIP.

Sow parsnip seed in the spring as soon as danger of hard frost is over, in drills 14 to 16 inches apart. Thin the plants to stand 3 inches apart in the rows. The cultivation of parsnips should be about the same as for beets and carrots. A crop may be planted in late summer for winter use, and the roots may be left in the ground through the winter or until needed, as freezing is believed to improve the flavor of parsnips. If it is desired to plow the garden before the parsnips are disposed of, they may be dug and stored in a cool place or buried in banks or pits.

Varieties recommended: Hollow Crown and Sugar.

PEAS.

Garden peas, sometimes called English peas, are not injured by light frosts, so they should be planted as soon as the soil can be put in order in the spring. The first plantings should be of small-growing, quick-maturing varieties, such as Alaska, First and Best, and Gradus, which do not require supports. These varieties should be followed by the large, wrinkled type of peas, such as Champion of England, Telephone, and Prize Taker. The large-growing varieties should be supported on brush, as shown in figure 19, on strings attached to stakes driven in the ground, or on wire netting. In order to have a continuous supply of peas, plantings should be made every 10 days or two weeks until warm weather. Peas should be planted in late summer and autumn for the fall garden, for which the early varieties are more desirable than the late ones.

Peas should be planted about 2 to 3 inches deep in rows 3 to 4 feet apart. Some gardeners, however, follow the practice of planting in double rows 6 inches apart with the ordinary space of 3 to 4 feet between these pairs of rows. This is a good practice with varieties requiring support, as the supports can be placed in the narrow space between the rows.

Varieties recommended: Alaska, First and Best, Gradus, Telephone, Champion of England, and Prize Taker.

PEPPERS.

Seeds of peppers should be sown in a hotbed or in a box in the house about eight weeks before the time for setting the plants in the garden. The plants are tender and should not be transplanted until the ground is warm and all danger of frost is past. Set the plants 15 to 18 inches apart in rows 2½ to 3 feet apart. The cultivation and treatment of peppers should be the same as that of tomatoes and eggplants. There is a large number of varieties of peppers, including the sweet kinds and the hot peppers.

Varieties recommended: Ruby King, Chinese Giant, Sweet Spanish, and Bell or Bull Nose, of the sweet peppers; Long Red Cayenne, Tabasco, and Red Cluster, of the hot types.

POTATOES.

Irish or white potatoes.—A small area of early potatoes should be grown in the garden, but the main crop should be grown elsewhere. Early potatoes should be planted as soon as the ground can be prepared to good advantage. In Florida, potatoes are usually planted in December, while in other sections of the lower South they are planted in January. In the upper South early potatoes are usually planted in February, but in the extreme northern portion of the South they are not planted until March. As it is difficult to keep potatoes through the summer, a fall crop should be grown. A common practice in some parts of the South is to plant potatoes from the first crop as soon as they are dug. In the lower South this method can be followed to advantage. Another method is to bed the potatoes on a little loose soil in a cool, shady place, covering the bed with litter or soil and moistening it thoroughly. As soon as the tubers sprout they are planted in the field for the late crop.

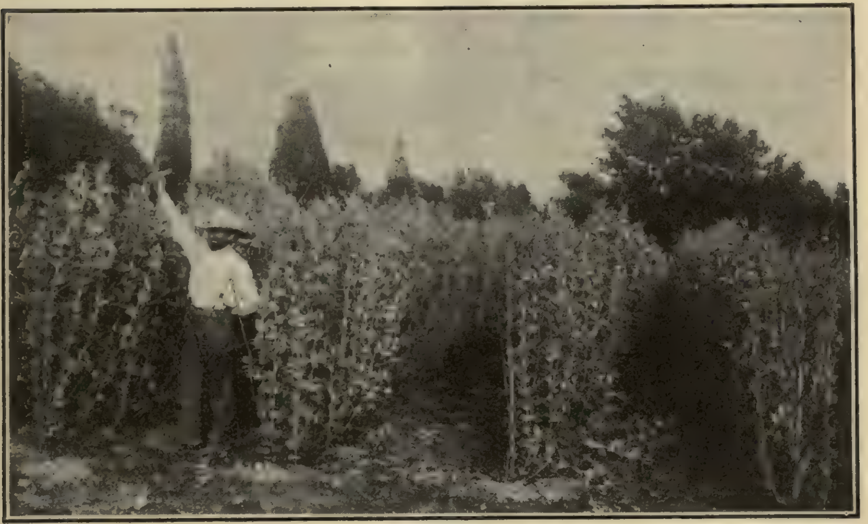

FIG. 19.—Tall-growing peas of the Telephone type supported on brush.

Potatoes are planted 12 to 14 inches apart in rows 2½ to 3 feet apart and covered to a depth of about 4 inches. Potatoes planted during hot weather should be covered 6 inches deep unless they have been sprouted before planting. The furrows are usually opened with a 1-horse turnplow, or lister, and the potatoes dropped, one piece in a place, in the bottom of the furrow. As it requires two or three weeks for potatoes to come up, it is important that they be cultivated as soon as the row can be followed. If a crust forms before the potatoes come up, a spike-tooth harrow or weeder should be run over the ground to loosen the surface of the soil. Harrow-toothed cultivators should be used for the main cultivation, but at the last cultivation the soil may be worked up around the plants to hold them erect and to protect the tubers from the sun.

After digging the early potatoes they should be kept in a cool, dry place during the hot weather of summer. In the lower South it is better to grow a fall crop rather than to try to keep the spring crop through the summer and winter. Fall-grown potatoes can be kept in a dry cellar, in a pit, or in any building where the temperature can be controlled. Irish potatoes keep best in a cool temperature, but should not be allowed to reach the freezing point. It is best not to allow the temperature to fall below 36° F.

Varieties recommended: Irish Cobbler, Triumph (Red Bliss or Bliss Triumph), and White Triumph are good early potatoes. Where only one variety is to be grown, the Irish Cobbler is recommended. The same varieties may be grown for the fall crop, or the Green Mountain and McCormick (also known as Lookout Mountain and Peachblow) may be planted. The McCormick is more likely to produce a good yield in the South than the Green Mountain, but is of rather poor quality.

For more complete information, read Farmers' Bulletin 407, entitled "The Potato as a Truck Crop."

Sweet potatoes.—The sweet potato is not usually handled as a garden crop in the South, but it is advisable to have a few plants in the garden for early summer use. On land that is not thoroughly drained, sweet-potato plants should be set on ridges which are thrown up by means of a plow. Two or four furrows are usually thrown together and leveled off with a light drag. The ridges should be broad, as narrow sharp ridges dry out quickly. The fertilizers recommended for general garden treatment will be found satisfactory for sweet potatoes. The roots that are too small for marketing are usually used for seed. For an early crop the roots should be bedded in a hotbed five or six weeks before it will be safe to set the plants in the field. As the plants are easily injured by cold, they should not be transplanted until danger of frost has passed. For the general crop in the lower South, select a protected location, preferably on the south side of a building or fence, and bed the roots in the open. A common method is to make an excavation 6 inches deep and of sufficient size to accommodate the roots to be bedded. Place in this a layer of sand or loose soil on which to bed the sweet potatoes. Put the roots close together, but do not allow them to touch, and cover them with sand or loose soil 1 to 2 inches deep. Soil on which sweet potatoes have been grown should not be used for the seed bed. Ten bushels of sweet potatoes will furnish enough slips to plant an acre. From these slips, if set out early, may be taken enough vine cuttings to plant 7 or 8 acres. Vine cuttings may be planted as late as July in the upper South and as late as August in the lower South. They will produce as large crops as slips, with less danger from the diseases which affect the roots.

Sweet potatoes should be dug on a bright day when the soil is dry. The time for digging varies in different sections, but the potatoes should be dug before there is any danger of hard frosts. When grown on a small scale, sweet potatoes may be dug with a spading fork. Great care should be taken not to bruise or injure the roots in handling. After digging, the roots should lie exposed for two or three hours to dry, after which they should be placed in a warm, well-ventilated room. The temperature during the curing period of about 10 days should be about 80° to 90° F. After the curing period the temperature should be lowered gradually to about 55° F. and held at that point during the remainder of the storage period. A small crop may be cured near the kitchen stove and afterwards stored in a dry room where there is no danger of their becoming chilled. Handle sweet potatoes as little as possible.

Varieties recommended: Pumpkin Yam, Dooley, Nancy Hall, Triumph, and Southern Queen. Where a dry-fleshed potato is desired, Improved Jersey, Big-Stem Jersey, and Triumph are recommended.

For further information on sweet-potato culture, read Farmers' Bulletins 324 and 548, entitled "Sweet Potatoes" and "Storing and Marketing Sweet Potatoes," respectively.

RADISH.

The radish is quite hardy and may be grown in the open all winter in the lower South and in coldframes in the upper South. Sow the seed in the open ground as soon as danger of hard frosts is over, or in coldframes whenever space is available. In the open, sow the seed in drills 12 to 15 inches apart and thin the plants to 1 inch apart. Successive plantings should be made every 10 days or two weeks until hot weather comes, and again in the autumn when the weather begins to get cool.

Varieties recommended: There are three types of radishes—turnip shaped, olive shaped, and long. Of the turnip shaped, the best varieties are the Scarlet Globe and Scarlet Turnip. The best of the olive-shaped sorts are the French Breakfast and Early Scarlet. The Long Scarlet Chartier, Long White Spanish, and Icicle are the best varieties of the long type.

RHUBARB.

Rhubarb can be grown in the upper South, but can not be grown satisfactorily in the lower South. For home use it is best to buy roots from a dealer rather than to grow plants from seed. Ten to twelve good hills are sufficient for the average family.

Set the roots 3 to 4 feet apart along the garden fence and manure heavily. The treatment suggested for asparagus is satisfactory for rhubarb. Do not allow the plants to go to seed.

SALSIFY, OR VEGETABLE OYSTER.

Sow seeds of salsify at the same time and in the same manner as those of parsnips and carrots. An ounce of seed will plant a 100-foot row and should be sufficient for an average family. After the plants are up, thin them to about 2 inches apart in the row. Salsify may be dug and stored the same as parsnips and carrots or left in the soil until needed. It is a biennial, and if the roots are not dug they will produce seed the second season.

Salsify deserves more general cultivation, as it is one of the most desirable root crops. It may be used in about the same way as parsnips. It is sometimes boiled, rolled in cracker crumbs, and fried in butter. Salsify when fried or used for making soup has a decided oyster flavor, from which it gets the name of vegetable oyster.

The Sandwich Island is the variety commonly grown.

SPINACH.

Spinach is one of the best crops grown for greens and should be found in every home garden. It can be grown in the open throughout the autumn and winter in all sections along the coast from Norfolk, Va., south and in the lower tier of Southern States. In the colder regions of the South it may need a little protection during the coldest weather. Two or three inches of hay, straw, or leaves will be a satisfactory protection, or the winter crop of spinach in the colder regions of the South may be grown in canvas-covered frames. The seed planted in the autumn will furnish greens through the winter and early spring.

Sow the seeds of spinach in drills 12 to 15 inches apart at the rate of 1 ounce to 100 feet of row. Three or four ounces of seed will produce enough greens for the average family. In gathering, the entire plant is removed. The large plants are selected first, and the smaller or later ones are thus given room to develop.

The Savoy is the variety most commonly grown.

SQUASH.

There are two types of squashes, the bush varieties and the running varieties. The bush varieties should be planted in hills 4 feet apart each way and the running varieties 8 to 10 feet apart each way. Squashes are prolific, and a supply for the average family will ordinarily be furnishel by five or six hills of each sort. Squash seed should not be planted until after danger of frost is over and the soil is quite warm. The cultivation and care of squashes should be the same as that given cucumbers or muskmelons.

The summer squash is prepared for the table in several ways. It may be boiled and eaten with butter, pepper, and salt, or it may be parboiled and then fried. It may also be sliced without boiling, soaked in water with a little salt, and then fried in egg and bread crumbs or cracker crumbs, like eggplant. Winter varieties are stewed or steamed, to be served with butter and salt, or are prepared in the same way for pie filling. They may also be baked and served in the shell, or the flesh may be scraped out after baking and served with butter and salt.

Varieties recommended: The varieties of summer squash commonly grown in the South are Pattypan, Summer Crookneck, and Vegetable Marrow. Of the winter squashes, the Delicious and Hubbard are among the best.

TOMATOES.

To get a crop of early tomatoes the seed should be started about eight weeks before the time for setting the plants in the field. In the lower South the plants can be grown in coldframes covered with canvas or cotton cloth, but in the upper South a hotbed should be employed. When only a few plants are needed the seed may be sown in a shallow box in the house. For the best results in growing tomatoes the young plants should be transplanted as soon as they reach a height of 1½ to 2 inches. Transplant these plants to stand 2 inches apart each way in a hotbed, coldframe, or box in the house. When the plants begin to crowd, it is a good plan to transplant them to flower pots, plant bands, old strawberry boxes, or tin cans from which the bottoms and tops have been melted.

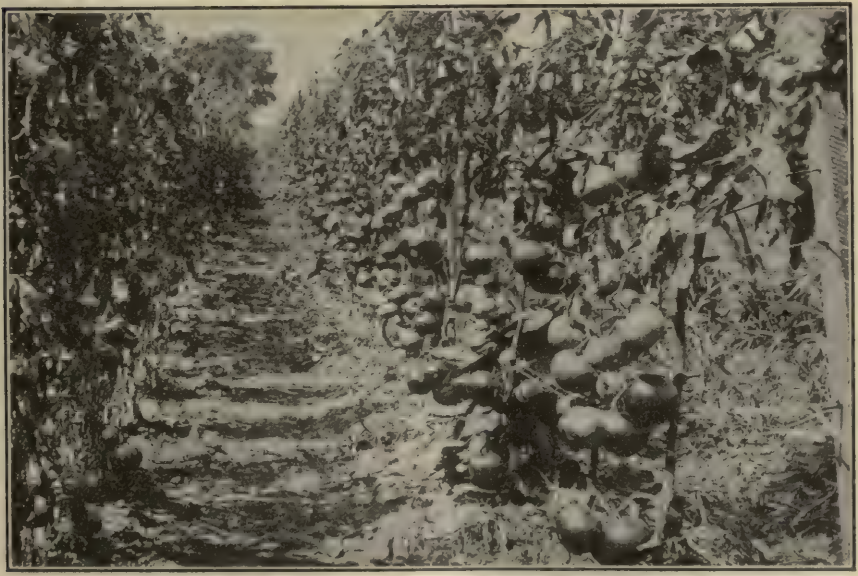

FIG. 20.—Tomato plants supported by strings attached to stakes driven in the ground.

Tomato plants should be set in the open as soon as danger of frost has passed. If the plants are to be pruned to one or two stems and tied to stakes, they should be set 18 inches apart in rows 3 feet apart. If the plants are not pruned or staked, they may be planted 3 feet apart in rows 4 feet apart. It is advisable, however, to prune and train to stakes, especially for the early crop, as plants so treated will be healthier and more easily cultivated and will produce fruit which is earlier and more uniform in size and shape than that produced by plants which have not been trained and pruned. Soon after setting the plants in the field, a stake should be driven near each plant, to which it may be tied. Care should be exercised to tie the plant so that it will not be injured by the string. A good plan is to loop the string around the stake and tie it under a leaf stem. Go over the patch once every week or ten days and remove all shoots starting in the axils of the leaves. Figure 20 shows a patch of tomatoes trained to strings attached to stakes driven in the ground.

Varieties recommended: For early tomatoes, Earliana or Chalk's Early Jewel is recommended, preferably the former. For medium and late varieties, the following are suggested: Greater Baltimore, Red Rock, Globe, Beauty, Acme, and Stone. The Stone is usually preferred for canning.

For further information on tomato culture, see Farmers' Bulletin 642, entitled "Tomato Growing in the South."

TURNIPS.

The turnip should be grown both as a spring and as a fall crop. For the spring crop, plant as early as the condition of the soil will permit, and for the fall crop sow the seed in late summer or early autumn. Sow the seed thickly in rows 15 to 18 inches apart, and as the plants reach a height of 4 or 5 inches begin thinning, using the young plants for greens. For good roots thin the plants to about 3 inches apart in the row. Cultivate turnips the same as carrots and parsnips. Turnips may be left in the ground until needed for the table, pulled and stored in a cellar, or buried in banks or pits.

Varieties recommended: Purple Top Globe, White Globe, Seven Top, White Milan, and Yellow Aberdeen.

Large quantities of rutabagas are shipped from the Northern States and Canada into the Southern States each year. While this crop is not commonly cultivated in the South, it may be grown as a fall and winter crop to very good advantage.

Rutabagas are planted the same as turnips, except that they require more room and a longer period of growth.

The Purple Top is the most common variety of rutabaga.

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THE SHEEP-KILLING DOG

J. F. WILSON
Animal Husbandry Division

FARMERS' BULLETIN 935

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Animal Industry
JOHN R. MOHLER, Chief

Washington, D. C. February, 1918

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WOOL AND MUTTON are commanding higher prices than ever before, and supplies of wool are being depleted so rapidly that it will take some time after peace is declared to restock the wool trade.

The sheep-killing dog constitutes one of the greatest menaces to the success of the sheep industry.

The dog not only kills sheep but keeps out of the sheep business men who are otherwise inclined to go into it.

The most effective method of dealing with the sheep-killing dog is through efficient legislation.

Notable progress has been made by several States in enacting good dog laws, and others are expected to take similar action.

No law, however well worded it may be, can be effective unless it is enforced and has the moral support of the people who are affected by it.

Uniform State dog laws are desirable.

THE SHEEP-KILLING DOG.[1]

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PRESENT STATUS OF THE SHEEP INDUSTRY.

Advancing prices for mutton, lamb, and wool have proved a stimulus for increasing the number of sheep kept on farms in the United States. Farmers in the East and in the Middle West are beginning to realize that sheep fit in well with any system of intensified farming and can be profitably kept without replacing other farm animals. Scientific management has demonstrated that parasites of sheep, once a source of great loss among flocks, are now within control by the farmer. The use of pastures and forage crops as supplements to the grain rations has been shown to be one of the most economical methods of fattening lambs for market. The 70-pound lamb is more popular today than ever before. Wool is in great demand at the highest prices in the history of the country. The war needs of the United States and her allies make it imperative that the numbers of live stock be substantially increased. The whole of Europe is contending with a great shortage of all classes of live stock and is facing a problem in the rehabilitation of the supply of farm animals that will not be solved for years after the war is over. The entire world is in need of wool, and it will take some time after peace is declared to restock the wool trade. The need of an increased meat supply and the necessity of a greater wool supply should make the sheep one of the most profitable of farm animals.

In the past various reasons have been ascribed as the causes for the constant decrease in the number of sheep kept on farms. The competition with western range sheep, low values for both mutton and wool, parasites internal and external, and greater profits to be derived from dairying have all had their part in discouraging flockmasters. But men who have entered the sheep business and have failed to find the keeping of sheep profitable are agreed that one of the greatest causes for their discouragement has been the sheep-killing dog.

The sheep-killing dog at the present time is still recognized as the greatest enemy of the eastern sheep owner. Thousands of sheep are ruthlessly killed every year by dogs, causing a monetary loss to sheep owners of well over a million dollars annually. Yet the greatest setback of all which the dog causes to the farm sheep industry as a whole consists in keeping out of the business men who are otherwise inclined to go into it. No farmer who wants to raise sheep is likely to attempt it while his neighbors' flocks are being killed outright or chased to death. The moral effect upon all persons who have seen sheep which have been wantonly destroyed or maimed by dogs is even more destructive to the industry than is the actual damage sustained. The humanitarian point of view alone should be of sufficient import to cause steps to be taken to put a stop to the depredation of the dog.

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[1] This bulletin supersedes Farmers' Bulletin 652.

NUMBER OF SHEEP KILLED BY DOGS.

That dogs are a real hindrance to the sheep industry is not only acclaimed by the testimony of thousands of sheep owners, but is verified by actual conservative satistics.

An investigation by the United States Department of Agriculture among sheep owners in 15 States east of the Rocky Mountains shows that out of a total of 6,836,492 sheep in the 502 counties reporting there were 34,683 killed by dogs in one year (1913) and paid for by the counties. At the same rate of loss in other farm States the total annual destruction of sheep by dogs would be 107,760 head. But these figures are based only upon the number actually paid for, and it is more than probable that the true losses far exceed this. It is known that many sheep are killed which are never reported to the county officials.

In 1913 crop reporters in 36 farm States submitted estimates which showed that the number of sheep in those States could be increased 150 per cent without displacing other live stock. Such an increase would place approximately 34,000,000 more sheep in these States than there are now. Of 1,411 answers received to the question as to whether sheep raising is profitable in the farm States, 887 answered "Yes." Of 894 answers as to the causes preventing increase in the numbers of sheep, 531 said "Dogs."

HABITS OF THE SHEEP-KILLING DOG.

Sheep-killing dogs work both singly and in groups, but usually in twos or threes. They do not limit their attacks to the flocks of the immediate vicinity in which they are kept, but travel for miles in all directions, spreading destruction in the flocks with which they come in contact. Because their work is so often done under the cover of darkness it is almost impossible to catch them in the act of worrying sheep, hence they can seldom be positively identified.

The ways in which different dogs attack and destroy sheep vary greatly. Some dogs simply kill one or two in a flock, while others continue the attack until all the sheep are either destroyed or crippled. In many cases where large numbers are killed they are neither bitten nor wounded but simply chased until they die from exhaustion.

After a dog has once formed the habit of killing sheep it seemingly becomes a mania with him and he is seldom if ever broken of it. He not only destroys sheep himself but leads other dogs to the work. No consideration should be given such dogs; if additional losses from this source are to be avoided, they should be killed as soon as their habits are known.

HOW DOG LOVERS CAN AID.

The dog rightfully holds a strong place in the minds and affections of men. The owner of a good dog finds in him a most faithful friend. But it sometimes happens that the dog most highly esteemed is also one that kills and worries the most sheep and is the most cunning in obscuring the evidences of his guilt. A well-bred dog's habit of lying innocently asleep in the front yard during the daytime is no proof that the same dog does not kill sheep at night. Because of the economic loss occasioned by sheep-killing dogs, and because such dogs bring the whole of their kind into bad repute, the true admirers and friends of this animal should help to further any steps likely to result in the limitation of the activity of these discrediting members of a noble race. One of the most practicable methods of accomplishing this result seems to be to place upon dogs such a tax as will reduce the number of superfluous ones and result in fewer being kept by persons who can not or will not give them the attention necessary to prevent the formation of habits and associations that lead to sheep killing.

DOG-PROOF FENCES.

A fence constructed in such a way as to be proof against dogs and coyotes has been designed and tried out by the Forest Service of the United States Department of Agriculture. A diagram showing the construction of such a fence is shown in figure 1. Small holes appearing after the wire is stretched can be filled in with dirt or other material.

Specifications for the dog-proof fence:

Posts 7½ feet in length, set 2½ feet in the ground and 16 feet apart; a barbed wire stretched flat to the surface of the ground; 3 inches higher a 36-inch woven-wire fence having a 4-inch triangular mesh; 5 inches higher a barbed wire; 6 inches higher a second barbed wire; 7 inches above this a third barbed wire. Total height, 57 inches.

It is essential that the bottom barbed wire be stretched flat on the surface of the ground at all points. This is accomplished by grading the ground before the fence is built and by filling in the small holes afterwards.

The farmer who does not object to placing his flock in a corral each night may eliminate the expense of building dog-proof fences around his entire farm by inclosing a small area with such a fence and making a practice of placing his flock therein at night. For such a purpose a 6-foot woven-wire fence such as that shown in figure 2 is suitable, but the coyote-proof fence constructed partly of barbed wire (fig. 1) is more efficient. Both dogs and coyotes are very shy of barbed wire.

DOG LAWS.

The desirability of a maximum increase in the number of sheep is generally admitted, and steps are being taken at the present time toward a rehabilitation of the sheep industry. It is recognized that one of the most effective means of insuring the farmer a profit on sheep is to make and enforce laws against the sheep-killing dog. Several States have recently passed laws which adequately protect the farmer's flock, but in most of the States the present dog laws fail in their purpose. Failure may also be caused by the nonenforcement of a good law already in existence, but more often it is caused by the nonexistence of a good law.

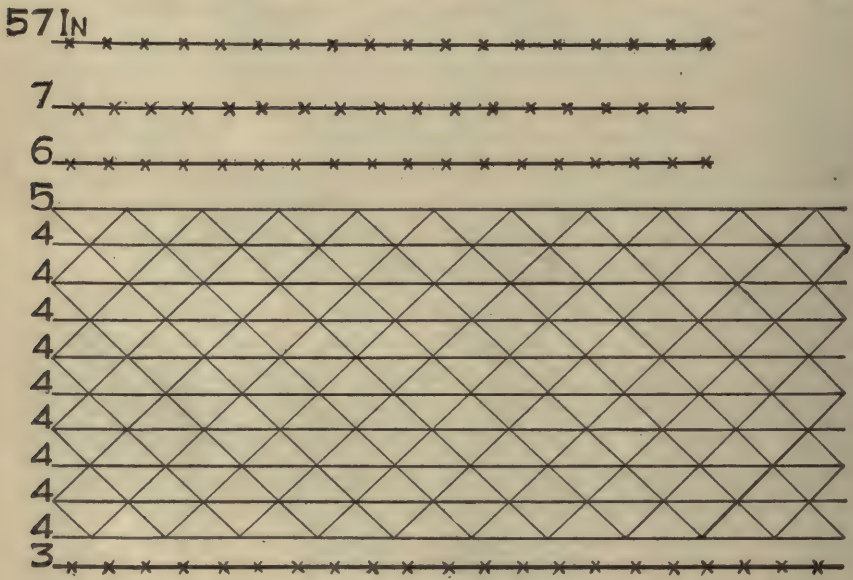

FIG. 1.—A dog-proof fence.

The following general discussion of those phases in the present dog laws of the farm States which should aid in the solution of the dog problem as related to the sheep industry will suffice to give an idea of the text of such laws.

Many of the States now levy dog taxes directly through the legislature, but there are still a number which empower cities and towns to tax dogs at their discretion. A State law which provides compensation for damages done by dogs has an advantage over municipal dog laws in that it gives the farmer compensation for damages done by dogs which live in the cities. Fortunately, most of the States where dogs are taxed only by the cities and towns are found in the western range country where the dog menace to the sheep industry is not nearly so pronounced as it is east of the Missouri River. The annual tax on dogs varies from 50 cents to $6 a head. Unspayed females usually are taxed at a higher rate than either males or spayed females.

There is no general method employed by the States in collecting dog taxes. Many States assess dogs along with other property and collect the tax as a personal one. This method enables the assessor to call personally on all the taxpayers, and it seems logical to suppose that a more complete list of dog owners can be obtained in this way. That is the case also where dog owners are required to visit the town clerk's office and present their dogs for registry. If the law levies a sufficiently high tax on dogs the collection of the tax is one of the most vital points in insuring the success of the law.

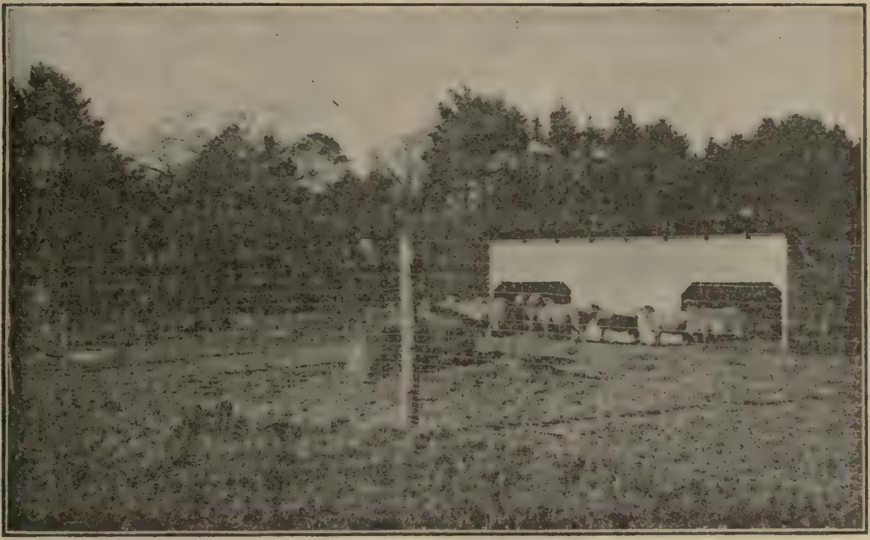

FIG. 2.—A dog-proof fenced lot in which sheep may be placed at night.

IDENTIFICATION OF LICENSED DOGS.

Not all of the States require that licensed dogs be identified. In those requiring it they are usually identified upon the registry books of the office issuing the license, by a statement of the breed, sex, and age, and a description giving color markings. To the public they are identified by a collar bearing a metal tag upon which is stamped the registry number of the dog, the year for which the license is issued, the place of issue or the State issuing the license, and in some cases the name of the owner of the dog. Nearly all of the States furnish such tags when the dog tax is paid, and a few furnish collars also. The practice of requiring the name of the owner of the dog to be stamped on the tag is to be commended, as it aids materially in establishing the identity of any dog caught in an act of wrongdoing. It is an easy matter for anyone to misread the number of a license.

DESTROYING THE SHEEP-KILLING DOG.

With few exceptions, the State laws allow anyone to kill a dog caught in the act of chasing, killing, or worrying sheep on land not owned by the owner of the dog. It is a provision which should be included in all State laws. Other conditions under which some of the States permit such dogs to be killed by anyone are:

1. When found at large unattended and without a collar bearing the registry number.
2. When found at large after having been proved to be sheep killers.
3. When found at large and unattended, between sunset and sunrise, on a farm where sheep are kept.

Many States have laws making it a misdemeanor punishable by fine or imprisonment to keep a dog which is known to have killed sheep.

A clause such as that found in Pennsylvania's dog law (enacted in 1917) requiring all dogs not under control to be confined between sunset and sunrise is highly desirable. Most of the damage by dogs is done at night, and it would seem that if such a law is effectually carried out the menace to the live-stock industry will be materially curtailed. Well-bred dogs and dogs highly prized by their owners are usually kept confined or restrained by their masters voluntarily; consequently such a clause works no great hardship on the owners of such dogs.

COMPENSATION TO SHEEP OWNERS.

The most recent laws provide for compensating the sheep owner from the dog-tax fund for losses caused by dogs. Damages are usually appraised by two or three disinterested persons appointed by the justice of the peace and residing in the locality wherein the loss has been sustained. In appraising the damage it is desirable to allow the full value.

Practically all of the States hold the dog owner liable for damages done by his dog. While this is a good clause, it should not supplant compensation by the State. The dog owner should be held liable to the State for damages paid out by the State. To one unfamiliar with the workings of dog laws it may seem that holding the dog owner liable is an effective method of protecting the flockmaster, but it must be remembered that in very few instances is it possible to ascertain the owner of the dog which has done the damage. Without compensation by the State the sheep owner has small protection from the dog nuisance.

Some of the State laws provide for the payment of damages only once a year and for prorating the damages if the dog fund is insufficient to allow for full compensation. The danger of having to prorate the amount paid out can be partially eliminated by increasing the dog-tax fund.

Possibly the most important consideration to bear in mind in drawing up a good dog law is to have a law that will command the moral support of the people. A poor law well enforced may be more protection to a sheep owner than a good law the enforcement of which is ignored by the people. A law must have behind it the will of the people if it is to be enforced by the authorities.

The ideal law is one which makes prevention of damage the major consideration rather than compensation for damage already sustained. Cooperation by the people and the publishing and distribution of copies of the law can be made of great benefit. Ignorance of such laws as do exist is often accountable for the little attention paid them.

UNIFORM STATE DOG LAWS.

It is believed that similar laws for all States, so enacted and enforced as to prevent damage to flocks by controlling and limiting the number of dogs and at the same time allowing the farmer greater leeway in protecting his flocks, will go far toward encouraging sheep raising and bring about a proportional increase in the number of sheep. With this in view an outline for a suggested dog law, combining parts of various State laws with some added features calculated to give the sheep owner the benefit in cases where proof of facts is difficult, is here presented. This is not the text of a complete dog law that will fit conditions in all States, but is intended as a suggestion which may be helpful in the preparation of future State dog laws.

OUTLINE FOR A SUGGESTED STATE DOG LAW.

1. All dogs over six months old to be listed by the county tax assessor at the time of listing other taxable property. (A more complete list of dog owners is obtained in this way than is the case when the dog owners are required to list their dogs.)

Tax to be as follows:

One male or spayed female	$2
Each additional male or spayed female	3
Each unspayed female	5

Kennel licenses to be issued with restrictions.

2. Dog owners to pay their dog tax and obtain a dog license at the same time other taxes are paid, unless proof is furnished that the dog has been disposed of.

3. Counties to furnish metal tags bearing the registration number of the dog and the name of the dog's owner. (This would eliminate any question arising as to the owner of a dog found at large or in the act of worrying stock.)

4. Provide for the impounding and, after a reasonable term of impoundment, the humane destruction of dogs found at large without collars bearing license tags.

5. All dogs to be confined from sunset to sunrise unless under leash or under reasonable control of their owners.

6. Dogs found at large between sunset and sunrise to be impounded and owner notified. Owner to regain custody of dog on paying a fine for violation of the law.

7. Any dog, registered or unregistered, may be killed by anyone when caught in the act of chasing, worrying, injuring, or killing sheep. Dog owner to have no recourse for the killing of such dog.

8. Any dog found running at large upon the inclosed lands of a person other than the owner of the dog may be killed at the time of finding him by the owner of the land, his agent, tenant, or employee.

9. Stock owners suffering losses from dogs to report the same to the local justice of the peace. Justice of the peace to appoint a committee of two or three disinterested farmers residing in the locality where the loss has been incurred, to appraise the damages. Committee to give the sheep owner a certificate showing in detail what the damages consist of and the amount. Damages beyond the value of the sheep actually killed outright should be allowed. Farmer to present the certificate to county commissioners to be passed on at the next session.

10. Compensation to be taken from money derived from the dog tax. Access to be had to State fund if dog-tax fund is insufficient to pay all claims.

11. Dog owner to be held liable to the county for all money paid out by the county for damages done by his dog, plus all costs of suit.

12. Reward of at least $10 to be offered by the county for the identification and proof of a sheep-killing dog.

13. Owner of a dog known to kill sheep to be required to kill, or cause to be killed, such dog within within 48 hours after notification under penalty of $5 and $1 per day thereafter until such dog is killed.

14. Sheep owner to be allowed to set out poison on his farm if he gives public notice of same.

15. Enforcement of the law to be the duty of every police officer in the State. State to furnish sufficient assistance, if necessary, to carry out all of the provisions of the act.

The suggestion is offered that sheep-breeders' associations or woolgrowers associations prepare mimeographed copies of the State dog law or a digest of the law featuring its salient points, and make arrangements with the officials issuing dog licenses to furnish each dog owner with a copy. Farmers should post in some conspicuous place on the farm the essential features of the law in order to warn the public of the rights which the law gives the farmer to kill dogs.

DIGEST OF EXISTING STATE DOG LAWS.

For the guidance of those who are interested in promoting legislation against sheep-killing dogs, there is presented here a digest of the existing dog laws of each State. This résumé does not set forth every item of the laws, but features the more important clauses as related to the protection of sheep.

ALABAMA.

Enacted 1915.

All dogs in Alabama over four months old are taxed $1 per head. The dogs are listed by the tax assessor and the taxes are collected as other taxes are. The law provides that owners of sheep who suffer losses from dogs report the loss to the district justice of the peace. The justice of the peace appoints two disinterested freeholders to examine and appraise the damages and the county pays the farmers the amount of the appraisement. Dog owners are held liable for damages done to persons if the damage is done off the dog owner's premises. Licensed dogs are given the same protection as other live stock. No person is allowed to keep a dog which has been known to kill or worry sheep and no action can be maintained against anyone for killing such a dog. Persons knowingly keeping a sheep-killing dog are liable for double the amount of the damages sustained. Indemnities for damage are taken from the dog tax fund. A further provision is that dogs must be confined at all times unless accompanied by their owners, but this provision must be adopted by the courts of the different counties before it is in force.

ARIZONA.

Revised Statutes of 1901 and Code of 1913.

The owner or keeper of any male dog four months old or over within one mile of the postoffice of any town of 1,500 population or more is required to pay a fee of $1 and for females $2. The constable of each precinct lists the dogs. Licensed dogs are required to wear a collar bearing a metal tag with the current year stamped on it, and the law requires that all dogs found at large without collars and tags be killed. No one can shoot, cripple, or poison a licensed dog. Moneys derived from the dog tax are used toward the public school fund. Cities and towns may also impose a license tax and adopt ordinances restraining dogs from running at large. No provisions are made to compensate owners of sheep for losses sustained through dogs.

ARKANSAS.

Enacted 1887. From "Digest of Statutes," 1916.

Arkansas empowers the council of any municipal corporation to place a tax on dogs, prevent them from running at large, and to authorize the destruction of dogs at its discretion. The owner of a dog is held liable for damages to sheep which are committed by the dog. If the sheep owner recognizes the dog and knows to whom it belongs, he takes action against the owner through the justice of the peace. Dog owners are liable for double the amount of damages done to sheep for a second offense committed by a dog belonging to the same owner.

CALIFORNIA.

1872. Civil Code, 1915.

All male dogs in the State which are over four months old are subject to a tax of $1, and all females over four months of age, $3. The dogs are listed by the assessors and taxes collected as other taxes. For each additional male there is a tax of $2. Dog owners are held liable for damages and costs of suit for all sheep, goats, or poultry killed or injured. It is not necessary for the dog owner to have had previous knowledge that the dog would worry, kill or wound sheep. If the dog is found in the act it may be killed at the time by anyone and the owner of the dog has no recourse. No provision is made for compensation to sheep owners unless the owner of the dog is known or is ascertained.

COLORADO.

Revised Statutes, 1912.

City councils are empowered to restrain dogs from running at large and to impose a license fee upon them. "Any dog found worrying or injuring sheep or cattle may be killed and the owner or harborer of such dog shall be liable for all damages done by it."

CONNECTICUT.

As amended in 1911.

Dogs are to be registered when 6 months old. Male dogs and spayed females are taxed $1 and unspayed females $5. The dogs are registered at the town clerk's office by the owners. An additional fee of 25 cents is charged for registration of the dog and issuance of the license tag. The license tag bears the name of the town where tag is issued and the license number, and must be worn by the dog at all times. The selectmen of each town appoint a dog warden whose instructions are to impound every dog found without a collar and plate. If the owner of such a dog is known he is notified and given an opportunity to reclaim the dog, otherwise the dog is killed after 72 hours or sold for not less than $5. Dogs found "pursuing, harassing, wounding, or worrying" any sheep, lambs, or other domestic animals may be killed by anyone. Dogs found at large between sunset and sunrise on a farm where sheep are kept may be killed unless the dog is owned by the occupant of the farm next adjoining that on which the sheep kept or next adjoining any highway which abuts such farm, or unless the dog is under muzzle or is accompanied by or within call of his owner. But even such a dog may be killed if there is reasonable apprehension that if not killed he will cause damage to domestic animals or if he has not a collar and plate.

Damages from dogs are reported by the sheep owner to a selectman of the town. The selectman and one other person who is named by the sheep owner appraise the damages. The town wherein the dog is registered pays the appraised damages and may recover from the dog owner if the owner is known. When the identity of such dogs has been established the "selectman shall order that such dogs shall be killed forthwith." The commissioner of domestic animals may make further regulations.

DELAWARE.

1893. From Revised Code of 1915.

Delaware's dog laws cover only two of the three counties in the State. the counties of New Castle and Sussex. In New Castle County the dogs are listed by the county assessors. Male dogs are taxed 50 cents and females $2. There is a further tax of $1 on each additional male dog. Sheep owners who suffer losses from dogs notify three "disinterested farmers" residing in the "hundred" where the loss occurs, and this committee of three appraises the damages. The committee gives the sheep owner a certificate showing the amount of the loss sustained. The sheep owner presents the certificate to the county treasurer, who pays the amount out of the collected dog taxes. The maximum amount which may be paid for losses is $5 for a sheep and $3 for a lamb. Any person may kill any dog not on the assessment list which is found at large without an owner. Any person may kill any dog caught in the act of killing or worrying sheep or lambs.

FLORIDA.

Compiled Laws, 1914.

The city and town councils are empowered to license and restrict the running at large of dogs. "Owners of dogs shall be liable for any damage done by their dogs to sheep or other domestic animals or live stock." "It shall be unlawful for any dog known to have killed sheep to roam about over the country unattended by a keeper. Any such dog found roaming over the country unattended shall be deemed a run-about dog and it shall be lawful to kill such dog." No provision is made for the compensation of sheep owners who suffer losses other than making he dog owner liable.

GEORGIA.

Enacted 1912. Code of 1914.

In the State of Georgia all dogs are made personal property and are given in and taxed the same as personal property. This clause makes the dog tax optional with each county. The only clause in the law which covers the entire State is one which states that owners of dogs are liable for damages and full costs of suit for injury done to live stock.

IDAHO.

1908 and 1915.

The session laws of Idaho for 1915 empower cities and villages to impose a tax on dogs of not less than $3 or more than $10 and to destroy any dog whose owner refuses to pay such tax. The 1908 law provides that "The owner, possessor, or harborer of any dog or animal that kills, worries or wounds any sheep * * * is liable to the owner of the same for the damages and the cost of suit to be recovered before any court of competent jurisdiction." It is not necessary in such a suit to show that the dog owner had knowledge of the fact that the dog would kill sheep. Any person finding any dog off the premises of its owner killing, wounding, or worrying sheep may kill the dog at the time of finding him.

ILLINOIS.

1907. From Revised Statutes 1915–16. Amended 1917.

In Illinois dogs are listed by the county assessors and taxed as other personal property. The assessor issues tags to be worn by dogs for which license is obtained. Males and spayed females are taxed $1 and unspayed females $3. City councils are also empowered to tax dogs and restrain them. Sheep owners may put poison on their farms for sheep-killing dogs. Owner of a dog is liable for all damages to sheep and if damages do not exceed $200 they may be recovered before a justice of the peace. Dogs discovered in the act of chasing sheep or in a condition showing that they have recently been engaged in chasing or killing sheep may be immediately killed by anyone. Moneys collected from dog taxes are used to pay for damages done to domestic animals by dogs. The owner of the sheep who suffers damages appears before a magistrate and makes affidavit as to the extent of his losses. The proof of damages must be made by at least two witnesses who are freeholders of that county. Recovery of damages from the county is possible only when the dog owner is unknown or is insolvent, but the payment of damages by the county does not bar the sheep owner from recovering damages from the dog owner. The amount of damages paid by the county shall not exceed $10 per head for sheep killed or injured.

INDIANA.

Revised Statutes 1914.

Dogs are listed by the township assessor and the dog owner pays immediately to the assessor $1 for each male or spayed female, $2 for each additional male or spayed female, or $3 for each unspayed female. It is unlawful for anyone to keep an unlicensed dog. Any dog known to have chased or worried or killed sheep may be killed by any person if found unaccompanied by its owner or keeper and if anyone keeps a dog which he knows to have chased, worried, or killed sheep, such owner is subject to a fine of from $10 to $50. "If any dog shall be found roaming over the country unattended by his master or owner or his owner's agent, it shall be lawful to kill such dog." Money derived from the dog tax is used to pay for damages to stock. The sheep owner reports his loss within 10 days to a township trustee and makes affidavit for losses, supported by two witnesses who are freeholders of the township. The distribution of funds is made only once a year and if the balance on hand is insufficient to satisfy all the claims presented, the money is prorated.

IOWA.

As amended 1917.

The county auditor of each county charges a registration fee of 50 cents on all dogs and furnishes a license tag to each dog owner. No dog is allowed to run at large between sunset and sunrise except while in the chase or accompanied by the owner or trainer. It is unlawful for any dog to run at large between sunset and sunrise unless it has been registered by the county auditor. "Any dog found at large and upon the lands of one other than its owner contrary to the provisions hereof shall be deemed a trespasser and may be lawfully killed by the owner, agent, employee, or occupant of said lands." The act, however, does not apply to dogs owned in cities which have their own dog regulation, while running at large within the limits of such city or town.

In the Code of 1913 provision is made that sheep owners may recover damages done by dogs from the county. Losses are reported within 10 days to the board of supervisors and must be verified by 2 witnesses. The board authorizes payment or disallows payment of damages at its next meeting. Payments are made twice a year and the dog fund is prorated if insufficient.

KANSAS.

General Statutes, 1915.

Dogs 3 months old and over are listed by the assessor. Males and spayed females are taxed $1 and unspayed females $2. The tax is collected as other taxes are. Cities are also empowered to tax dogs and to restrict them. If the owner of a dog disclaims ownership he may avoid the dog tax by killing the dog in the presence of the assessor. The 1911 law makes a dog owner liable for damages done to sheep, damages to be recovered in court by the sheep owner. The law of 1868 legalizes killing any dog at any time which may be found worrying or injuring sheep.

KENTUCKY.

1906. General Statutes, 1915.

Dogs over 4 months old are listed by the assessor and taxed $1 for either sex. Dog tax funds used to indemnify losses of sheep. The sheep owner notifies the magistrate of the district of his damage. The magistrate appoints two disinterested freeholders of the neighborhood to appraise the damages and report same. The report is filed with the county clerk and acted upon by the fiscal court. Dog fund is prorated if insufficient to compensate all damage claims allowed. The dog owner is liable for the damages if they occurred off his premises and court may order such a dog killed. There is a fine of $10 for failure or refusal to list a dog with the assessor. Unlicensed dogs are to be killed.

LOUISIANA.

Amended 1910. From Revised Statutes, 1915.

Dogs are listed by the assessor. The police juries of the State are required to impose a tax on dogs not to exceed $2. Dog tax fund is given to school boards. Police juries are authorized to pass ordinances for the protection of sheep and to impose fines and penalties as they deem proper. There is a heavy fine or imprisonment or both for violating a police jury ordinance. A petition signed by 50 taxpayers of any parish will force the police jury of that parish to pass ordinances regulating dogs. Anyone may kill a sheep-killing dog. A dog owner is liable to a sheep owner for 10 times the damages caused to sheep. Persons knowingly keeping sheep-killing dogs are liable to a $25 fine or 30 days imprisonment or both.

MAINE.

1909.

Tax assessors list all dogs. Owners must register same with the town clerk. The tax is $1.15 for males and spayed females and $5.15 for unspayed females; kennel license $10.15. Dogs must at all times wear a collar showing the name of owner and dog's registry number. All dogs not licensed are to be killed by police officers. "Whenever any sheep, lambs, or other domestic animals owned by a resident of this State are killed or injured by dogs, such owner may make complaint thereof to the mayor of the city, or to one of the municipal officers of the town or plantation where such damage was done, within seven days after he has knowledge of the same, and thereupon the municipal officers shall investigate the complaint and if satisfied that the said damage was committed by dogs within the limits of their city, town, or plantation, they shall estimate the damage thereof according to the full value and fifty per cent additional, for the purpose for which they are kept, whether as breeders or for other purposes, and direct that the same shall be paid from the town treasury." The town has right of action against the dog owner to recover the amount so paid out. Any person who keeps a dog that kills or injures sheep or lambs is subject to fine of $50 to $100 unless dog is killed before case is disposed of. If the dog owner is unknown the State reimburses the owner. Any person may kill any dog caught chasing sheep off the dog owner's land.

MARYLAND.

1912 and 1916.

The State dog laws are applicable only to certain counties. The boards of county commissioners are empowered to levy taxes at the rate of not less than $1 for males and $2 for females, with the exception of Hartford County, where a uniform tax of $1 may be levied. In Allegany County any person may kill any dog found chasing or killing sheep, cattle, or poultry upon the lands of any person other than the owner of the dog, or the dog may be killed if found unattended in an inclosure where sheep are kept, except on the farm of the dog owner. No person has the right of action to recover the value of a dog so killed. The county commissioners pay $10 to anyone identifying a sheep-killing dog and the owner of the dog is notified to kill it. Failure to kill a dog after being notified to do so subjects the owner to a fine. Montgomery County permits the appointment of appraisers to estimate the damage done by dogs and the county awards compensation to sheep owner. Owner of dog is held liable if he is known. If a dog is known to kill animals or fowls any person may kill the dog and dog owner has no recourse.

MASSACHUSETTS.

As amended 1917.

Under the existing law male dogs and spayed females over 3 months of age are taxed $2 and unspayed females $3. Each dog must wear a collar and a license tag showing the name of the owner and the dog's registration number. Any dog found out of the care of its owner and worrying, wounding, or killing sheep on land owned by one other than the owner of the dog may be killed. Cities and towns are empowered to offer rewards up to $25 for anyone killing a dog which is found harrassing or killing sheep. Damages are appraised and paid for by the county. In 1917 a provision was added whereby persons who obtained dog licenses promise to restrain the dog from "killing, chasing, or harassing" sheep. Dissatisfaction with the existing statutes led the 1917 legislature to adopt a resolution whereby a commission is to be appointed to inquire into the advisability of amending or supplementing the existing laws. The commission's report is to be ready in January, 1918.

MICHIGAN.

As amended 1917.

Owners of dogs over 4 months old must secure from the clerk of the village or township a metal registration tag and law provides that said tag shall be "securely fastened to the collar of the dog and constantly worn by such dog." Males and spayed females are taxed $2 and unspayed females $5. County assessors are also required to list the dogs in each county. Sheriff shall kill dogs for which tax is not paid. Damages to live stock are appraised by a local justice of the peace, who gives a certificate stipulating the amount of the damages to the local clerk of the township or village. The clerk then issues an order, payable to the stock owner, drawn on the treasurer of the township or village. Surplus funds at the end of the year go to the school fund. "Nothing in this act contained shall be construed as limiting the common-law liability of the owner of a dog for damage committed by it." Act does not apply to cities already having ordinances providing for the disposition of fees derived from dog taxes.

MINNESOTA.

As amended 1915.

Village councils are empowered to license dogs and to restrain them from running at large. Dog owners are liable to owners of domestic animals for damages done by their dogs, even though dog owners are unaware of the dogs' bad habits. Persons knowingly keeping a dog which has bitten any domestic animal are liable to a fine of $5 a day for every day that the dog is kept on such person's premises thereafter. Any dog found injuring or worrying sheep may be killed by anyone and "any owner of sheep may kill any dog found on his premises where sheep are kept, if not under the restraint or control of his owner or other person."

MISSISSIPPI.

Enacted 1910.

The board of supervisors of each county is empowered to tax dogs 6 months old or more. If the dog tax is adopted in a county the rate is to be $1 for males and $3 for females. The dogs are recorded by the tax assessor and the taxes collected are used for the repair and improvement of public schoolhouses. All dogs in counties requiring a license must wear a collar bearing the name of the owner. If the board of supervisors refuses to levy the tax, a petition from 20 per cent of the qualified electors of the county will grant the people in that county a special election on the subject. When any county levies a tax it must be levied each year thereafter unless voted down in the foregoing manner. In counties requiring the license any person may kill any dog found at large without a collar and license tag, and the dog owner has no right of action.

MISSOURI.

Revised Statutes of 1909.

Municipalities are empowered to tax dogs at their discretion. If sheep or other domestic animals are killed by dogs the owner of the stock so lost may recover against the owner of the dog the full amount of the damages and the dog owner must kill the dog or forfeit $1 for every day he refuses to do so. Under "general application" in the "Revised Statutes of 1909" it is held that anyone may kill a dog which has killed sheep, except that no one may kill such a dog on the dog owner's property. In order to recover damages for sheep killed by dogs, it is necessary to allege and prove that the owner of the dog knew of his vicious character. "A person has no right to put poisoned meat on his premises to kill dogs merely trespassing. But if the dogs have killed his sheep, he has the right to poison them."

MONTANA.

1903.

Municipalities are empowered to tax dogs at their discretion and to restrict them from running at large. The law makes it a misdemeanor for a dog owner to allow his dog to chase any live stock on the public range which does not belong to himself. The penalty for such misdemeanor is a fine not to exceed $50.

NEBRASKA.

From Code of 1913.

Dogs are considered personal property. The municipal authorities of the counties, cities, towns, and townships are empowered to impose a tax on each dog of not more than $5. Any person may kill any dog found doing damage to any domestic animal except dogs, and any one having reasonable grounds to believe that a dog has been killing, wounding, chasing, or worrying sheep may kill such a dog. Every dog must wear a collar bearing a metal plate on which is inscribed the name of the owner. It is lawful to kill any dog found at large without such a collar. Dog owners are liable to stock owners for damages done by their dogs and are also subject to fine for allowing the dog to damage stock. The damages, however, must be obtained through an action brought against the dog owner in court. Funds raised through the taxation of dogs are in most cases to be used for compensation for damages done to stock by dogs, but in certain of the larger cities the dog fund is turned over to the city treasurer to be used as the council directs.

NEVADA.

Revised Laws of 1912.

City councils are empowered to tax dogs and to regulate the destruction of all unlicensed dogs. A heavy fine is imposed on any one who keeps a vicious dog. It is unlawful to poison any dog intentionally.

NEW HAMPSHIRE.

1913 and 1915.

All dogs over three months of age are to be taxed. The tax on males and spayed females is $2 and on unspayed females $3. Dogs are required to wear a collar bearing the owner's name and the registry number of the dog. No self-hunting dogs allowed to run at large "in woods or fields inhabited by game birds or quadrupeds or on lands where sheep are pastured between April first and December first of any year." When a dog is discovered "pursuing or harassing" sheep "or injuring any domestic creature" notice is given the owner of the dog and on second or any subsequent offense the dog owner may be fined $5. A dog found out of the care of its owner wounding, worrying, or killing sheep may be killed by anyone. Sheep owners may recover damages done to sheep from the "town or city wherein such damage was done."

NEW JERSEY.

As amended 1911–15, 1916–17.

All cities, towns, and villages tax male dogs at $1 and females $2, but townships may levy additional dog taxes up to $5. Dog owners are required to register their dogs with the town clerk. Each municipal corporation is required to make ordinances for the seizure and killing of all dogs not claimed by any person. All municipal corporations required to enforce the State law by ordinance. Licensed dogs are required to wear a collar containing the license number of the dog and the name of the owner. Owners of dogs are liable for damage done to sheep. If any dog is known to be a sheep killer the owner must kill the dog or cause it to be killed; penalty for failure to kill a dog after being notified to do so subjects the owner to a fine of $10. Dogs caught killing, wounding, or chasing sheep may be killed by any one, and a dog found at large without a collar may be killed. The 1916 amendment provides for the appraisal of damages to live stock by two freeholders and compensation for such damages from the dog-tax fund. The 1917 law prohibits dogs running at large during certain seasons, except when accompanied and controlled by their masters or being trained.

NEW MEXICO.

Codification of 1915.

The State law requires all cities, towns, and villages to collect a tax of $1 on each male dog and $2 on each female, for municipal purposes. A fine of $10 is imposed on persons who keep a dog and do not pay the tax. A sheep owner has a right of action on the owner of a sheep-killing dog and such dog must be killed by its owner. Each municipality is required to make ordinances regulating the running at large of dogs. No one is allowed to keep a sheep-killing or a vicious dog.

NEW YORK.

Enacted 1917.

Male dogs over four months old are taxed $2 and females $3. The license is obtained from the town or city clerk. Every licensed dog is required to be tagged and unlicensed dogs to be killed. Any person may kill any dog while it is "attacking, chasing, or worrying" any domestic animal or is attacking fowls. If the commissioner of agriculture decides that the State regulations are inadequate, he may publish an order that the dogs in such town be confined at night from May 1 to November 1, or any shorter period of time within these dates. The owner of a dog is liable for all damages done by it. "The fact that a dog is without a tag attached to a collar * * * shall be presumptive evidence that such dog is unlicensed and that a tag was not issued and attached as so required. An action shall not be maintained for an injury to or destruction of a dog without a tag" unless the owner can prove that the dog had a tag which was removed without his knowledge or consent. The commissioner of agriculture on his own motion or the application of at least two residents may issue an order restraining the owner of a dog which is "dangerous to persons, domestic animals, or fowls" to run at large outside the premises of the owner, for any length of time specified in the order. If dog owner permits his dog to run at large after receiving such an order he is subject to a fine of $25. Failure to have a dog licensed causes the dog to be killed if tax is not paid by the owner within five days after the dog is impounded. Dog owners are held liable for all damages done to live stock and in the case of sheep there is added to the amount of the damages $2 for each ewe of the age of one year or upwards, in the flock "attacked, chased, or worried by such dog." Owners of stock which has been "attacked, chased, worried, injured, or killed by a dog" may present a claim for damages to the commissioner of agriculture, and the commissioner causes an investigation and determines the amount to be paid. Reimbursement is made from the State treasurer's office. Anyone killing a dog must report the same to some village or city official or pay a fine of $10. Damages paid for by the State are taken from the dog-tax fund.

NORTH CAROLINA.

1913.

North Carolina has no State-wide laws on the dog question. The law must be accepted by each county before it is in force. Upon application of one-third of the qualified voters of a county an election may be held to determine whether or not the dog law is wanted. No dogs can be taxed less than $1 or more than $5. Failure to register dogs in counties which have adopted the dog law is a misdemeanor punishable by fine. Anyone can kill a mad dog, sheep-killing dog, or egg-sucking dog on sight, and the owner of the dog can not recover damages. The dog owner is held liable for all damages done to sheep by his dog.

NORTH DAKOTA.

Compiled Laws of 1913.

Municipalities are empowered to tax dogs at their discretion. Dogs caught in the act of killing, wounding, or chasing sheep, or dogs showing that they have recently been engaged in killing, wounding, or chasing sheep may be immediately killed by any person. The owner of a dog is held liable for all damages done to sheep or to other domestic animals.

OHIO.

Enacted 1917.

All dogs over three months of age are to be taxed. The tax on males and spayed females is $1 and on unspayed females $2. The certificate of registration is obtained from the county auditor. Unlicensed dogs are to be killed. Licensed dogs must wear their metal tags at all times, and failure to wear the tag is evidence of lack of registration. County sheriffs are instructed to seize and impound all dogs found without registration tags and to sell or destroy such dogs if they are not redeemed within four days. Claims for damages to live stock are presented to the township trustees and must be verified by the testimony of at least two freeholders. Sheep owner must make it known that he does not know the owner of the dog which did the damage, or that damages could not be collected from the dog owner. The county commissioners pass on claims and pay them in June or in December. The dog fund is prorated if insufficient. If stock owner is dissatisfied with the allowance made by the commissioners he may appeal to the probate court. It is lawful to kill any dog caught worrying or chasing sheep. Dog owner is liable for damages done by his dog.

OKLAHOMA.

Revised Laws of 1910.

The dogs are taxed and restrained at the option of city councils. The State law empowers the city councils to prevent dogs running at large. A dog found off his owner's premises in the act of killing or worrying sheep may be killed.

OREGON.

Enacted 1917.

Sheep owners suffering losses present claims for damages to the board of county commissioners. The board allows or disallows the claims and if passed upon favorably the damages are paid by the county out of the dog-tax fund. The law has been attacked as unconstitutional and is at present in litigation. The State law as passed refers only to certain portions of Oregon specified as " lying west of the summit of the Cascade Mountains with the exception of the counties of Josephine, Jackson, Coos, Curry, Lincoln, Tillamook, Clatsop, and Columbia." A tax of $1.50 is imposed on all males over six months of age and spayed females, and $3 on unspayed females of the same age. The tax is collected by the constable of each district. The law does not apply to cities having a population of 100,000 or over. Compensation is made to stock owners for losses incurred through dogs.

PENNSYLVANIA.

Enacted 1917.

The license fee for dogs is determined by the county commissioners of each county, but may not exceed $2 for each male or spayed female, or $4 for each unspayed female. No dog is allowed to run at large unaccompanied by its owner. Unlicensed dogs are to be killed unless claimed by the owner after being impounded. "Any person may kill any dog which he sees in the act of pursuing, worrying, or wounding any live stock or poultry or attacking human beings, whether or not such dog bears the license tag required." "Any unlicensed dog that enters any field shall constitute a private nuisance, and the owner or tenant of such field or their agent or servant may kill such dog while it is in the field without liability or responsibility of any nature for such killing." Licensed dogs accompaned by the owner are not subject to the foregoing clause unless caught in the act of worrying, wounding, or killing any live stock or poultry. No one is allowed to put poison out for dogs. Every dog is required to be confined or secured by collar and chain or other device between sunset and sunrise every day. Owners of dogs are responsible for damage done to live stock by their dogs. Damages to sheep are appraised by a justice of the peace or by an alderman and are paid for by the county. If the owner of a dog which has committed damages is known he must pay the amount of the damages to the county or kill the dog. (Full text of law on page 24.)

RHODE ISLAND.

As amended 1916.

Owners are required to register their dogs with the town clerk in April of each year. The tax is $1.15 on males and spayed females and $5.15 on unspayed females Licensed dogs are required to have at all times a collar bearing the dog's registry number and the name of the owner. There is a fine of $10 for owning or keeping a dog not registered. Dogs kept for breeding purposes only and confined or kept in charge of owner at all times need not be registered if a kennel license is paid. It is lawful to kill any dog found off the premises of its owner unattended and without a collar. The dog owner is liable for all damages done by his dog, same to be recovered by an action in court. The dog owner is liable for double the amount of damages to live stock for a second offense committed by the dog and for a second offense the dog is ordered killed. Towns annually appoint appraisers to appraise damages to live stock. These appraisers give a statement of the amount of damages to the sheep owner. The sheep owner presents the statement to the city council and the city council draws an order on the town treasurer for the amount. The town may recover from the dog owner or the sheep owner may recover from the dog owner, but if the sheep owner prefers to sue the owner of the dog he can not recover from the town.

SOUTH CAROLINA.

Code of 1912.

The State law requires that dogs be listed as personal property at the time other assessments are made. A tax of 50 cents is imposed on all dogs except those in Harry County where the tax is $1. The law specifies that "It shall be lawful for any person who may find a dog in the act of worrying or destroying any sheep in this State to kill said dog, and he shall not be held to answer for any action, civil or criminal." The owner of a dog is liable for double the damages that may be inflicted by the dog on sheep, but the damages must be recovered at the suit of the party sustaining the loss.

SOUTH DAKOTA.

Code of 1903.

Dogs are listed in each county by the county assessor and a tax of $1 on each dog is levied by the county commisioners. "Any person keeping, owning, or harboring" a dog which "chases, worries, or kills" sheep is liable for all damages committed by such dog. Any person may kill any dog which is found off the premises of its owner in the act of chasing or worrying sheep.

TENNESSEE.

1907. From 1917 edition of Shannon's Code of 1896.

Female dogs three months of age or over must be registered with the county clerk. The tax is $3 and a collar and a tag bearing the name of the county and the registry number is furnished. There is a fine of from $5 to $25 for not registering a female dog. It is unlawful to allow any dog to run at large uncontrolled by its owner except when in the chase. It is a misdemeanor for anyone to keep a dog after notice has been served that such dog has chased or killed sheep. The owner of a dog is liable for all damages done to live stock and ignorance of the dog's habits does not free his owner from liability.

TEXAS.

Revised Civil Statutes of 1911.

The State empowers each county to place a tax on dogs at its discretion, and to prevent dogs from running at large. The law contains no clause regarding damages to sheep.

UTAH.

Amended 1911.

Counties, cities, and towns are empowered to tax. The law is essentially the same as that of Texas.

VERMONT.

As amended in 1912.

All dogs which are four weeks old or over on April 1 are to be registered with the town clerk by their owners. At the time of registry a tax of $1 is levied on owners of male dogs and spayed females and a tax of $6 on unspayed females. Dogs not four weeks old on April 1 are registered the following year. If a dog which is known to be vicious is registered, the owner of the dog is subjected to a fine of $20. Licensed dogs are required to wear collars and unlicensed dogs are to be killed. Sheep owners suffering damage from dogs report their losses and the damages are appraised either by a selectman of the town or by two disinterested parties. Reparation is made by the town from the dog tax fund. If the dog or dogs which have done the damage are identified they are to be killed. Villages may offer rewards for the identification of a sheep-killing dog. The owner of a dog is liable to the town for all damages done by his dog which the town paid for. If the sheep owner wishes he may sue the dog owner instead of recovering damages from the town, and in such instances the owner is liable for twice the amount of the damages plus twice the cost of suit.

VIRGINIA.

1914 and Code of 1916.

The commissioners of revenue list all dogs as personal property and to be taxed as such. Males and spayed females are taxed 50 cents and unspayed females $1. Damages, not to exceed the value of sheep, appraised by three qualified voters chosen by the justice of peace, are paid from dog tax by the county, the fund being prorated if insufficient. The law does not apply to municipalities having their own dog laws, to counties having special dog tax, or to Caroline, Nansemond, Isle of Wight, or Lancaster Counties. An act of 1916 provides the same measure for Clarke, Frederick, and Charlotte Counties, but taxing all dogs 75 cents and applying fund to expenses of enforcing the law, damages for sheep, and the destruction of predatory animals. A law of 1914, which does not apply to any city or town requiring a license tax and must be adopted by each county before becoming effective therein, makes it a misdemeanor to fail to confine a dog to the limits of the premises on which he is regularly kept, when unaccompanied by the owner.

WASHINGTON.

Code of 1915. Amended 1917.

The law as given in the 1915 code empowers cities or townships to license dogs and to make ordinances restraining dogs from running at large. The 1917 amendment states that any person can kill any dog found "chasing, biting, injuring, or killing" sheep off the dog owner's premises, but if not killed the dog shall thereafter be kept in leash or confined. If the dog thereafter runs at large any person can kill it. The owner of a dog which has been identified as a sheep killer is notified to kill it within 48 hours and failure so to do imposes a fine on the owner of not less than $5, and $1 per day thereafter until such dog is killed. The act does not apply to cities of the first or second class, which regulate the licensing of dogs by ordinance.

WEST VIRGINIA.

Enacted 1917.

County courts and municipal councils issue license to dog owners upon application. There is a tax of 25 cents on all dogs. It is unlawful for anyone to allow his or her dog to run at large on any inclosed land or to trespass upon any land belonging to another. If any dog is permitted to run at large or to "kill or assist in killing, injuring or chasing" sheep the proof that the dog was at large at the time and at place of the injury complained of, is evidence of the guilt of the dog. Any dog found at large in any public place without owner or keeper is seized. No unnaturalized resident can own a dog. Anyone violating the law is subject to fine. The dog owner is liable for all damages done to sheep if the sheep owner successfully prosecutes him. (Full text of law on page 31.)

WISCONSIN.

General Statutes 1915.

The State empowers towns and municipalities to tax dogs not less than $1 nor more than $10 and also to make regulations concerning dogs running at large. "Any person may kill any dog * * * found killing, wounding, or worrying" sheep, lambs, or other domestic animals. The owner of a dog is liable for all damages done by his dog even though said owner is ignorant of the disposition of the dog to kill, wound, or worry farm animals. If a dog owner is notified that his dog is worrying or killing live stock he is required to keep the animal confined. After being notified to confine the dog, the owner is liable for double the amount of the damage done by the dog in a second offense, but the damages are to be recovered by the owner of the live stock who suffers the loss. Also the dog, after the first offense may be killed if found off the owner's premises. Neither the State nor the counties make compensation for losses incurred through dogs.

WYOMING.

Towns and municipalities are empowered to tax at their discretion. Dogs used in the forest reserves for the purpose of hunting must be licensed and tagged. On such dogs the tax is $1. Dogs caught in the act of chasing live stock may be killed in cases where the safety of the stock is threatened, provided the stock so threatened is not upon land belonging to the owner of the dog.

COMPLETE DOG LAWS OF PENNSYLVANIA AND WEST VIRGINIA.

The complete laws of the States of Pennsylvania and West Virginia are given as being examples of modern laws which really offer protection to flockmasters. While the text of these laws will not be suited to every State, their principles could be adopted to advantage.

THE DOG LAW OF PENNSYLVANIA.

AN ACT relating to dogs, and the protection of live stock and poultry from damage by dogs; providing for the licensing of dogs; regulating the keeping of dogs, and authorizing their destruction in certain cases; providing for the protection of licensed dogs, and for dogs temporarily imported for trial, show, and breeding purposes; prescribing certain privileges for hunting dogs, and dogs owned or used by the Board of Game Commissioners; providing for the assessment of damages done by dogs, and payment thereof by the proper county to the owners of live stock and poultry, and of damages to licensed dogs; imposing powers and duties on certain State, county, city, borough, town, and township officers and employees, and on city councils of cities of the first and second class; and providing penalties.

SECTION 1. *Be it enacted, etc.*, That this act shall be known and may be cited as the Dog Law of One Thousand Nine Hundred and Seventeen.

SEC. 2. For the purpose of this act the following terms shall have the following meanings respectively designated for each:

The term "live stock" shall include horses, stallions, colts, geldings, mares, sheep, rams, lambs, bulls, bullocks, steers, heifers, cows, calves, mules, jacks, jennets, burros, goats, kids, and swine.

The term "poultry" shall include all domestic fowl.

The word "person" shall include State and local officers or employes, individuals, corporations, copartnerships, and associations. Singular words shall include the plural. Masculine words shall include the feminine and neuter.

The word "owner," when applied to the proprietorship of a dog, shall include every person having a right of property in such dog, and every person who keeps or harbors such dog or has it in his care, and every person who permits such dog to remain on or about any premises occupied by him.

SEC. 3. The term "kennel" shall mean any establishment wherein or whereon dogs are kept for the purpose of breeding, sale, or sporting purposes.

The term "police officer" shall mean any person employed or elected by this Commonwealth, or by any municipality, county, or township, and whose duty it is to preserve peace or to make arrests or to enforce the law. The term includes game, fish and forest-wardens.

SEC. 4. On or before the fifteenth day of January, one thousand nine hundred and eighteen, and on or before the fifteenth day of January of each year thereafter, the owner of any dog six months old or over shall apply to the county treasurer, either orally or in writing, for a license for each such dog owned or kept by him. Such application shall state the breed, sex, age, color, and markings of such dog, and the name and address of the last previous owner; and shall be accompanied by a fee of not less than one dollar, nor more than two dollars, for each male dog and each spayed female dog; and by a fee of not less than two dollars, nor more than four dollars, for each unspayed female dog. The license fee shall be determined by the commissioners of the several counties of the State, and shall be the only license or tax required for the ownership or keeping of said dog or dogs.

SEC. 5. Such license shall be issued on a form prepared and supplied by the county commissioners. Such license shall be dated and numbered, and shall bear the name of the county issuing it and a description of the dog licensed. All licenses shall be void upon the fifteenth day of January of the following year. The county commissioners shall also furnish, and the county treasurer shall issue, with each license, a metal tag. Such tag shall be affixed to a substantial collar. The collar shall be furnished by the owner, and with the tag attached shall at all times be kept on the dog for which the license is issued, except when confined in the kennel; and except, also, that dogs owned or used by the Board of Game Commissioners of the Commonwealth, or their special deputy game-protectors, servants, agents, and employes, shall not be required to wear the collar and tag aforesaid when used in hunting wildcat and bear during the winter months of December, January and February in each and every year.

SEC. 6. The county commissioners shall prepare, and furnish annually to the county treasurer, metal tags to be given by the county treasurer to the owners of dogs when such owners shall pay the license fee for said dogs. Such tags shall be of metal, and shall bear the name of the county issuing it, and a serial number corresponding with the number on the license issued to said owner, as provided in the preceding section of this act. Such tags shall also have impressed thereon the calendar year for which such tag is issued, and shall not be more than one inch in length, and shall be equipped with a substantial metal fastening device. The general shape of said tag shall be changed from year to year.

If any such tag is lost it shall be replaced without cost by the county treasurer, upon application by the person to whom the original license was issued, and upon production of such license.

SEC. 7. Any justice of the peace within the county who has qualified by having applied to the county treasurer, and having received and receipted for necessary blanks and tags, may issue such dog license and tags in like manner as prescribed for the issuance of licenses by the county treasurer. When a license is issued by a justice of the peace the person applying for the license shall pay fifteen cents to the said justice, in addition to the other fees prescribed as the cost of said license. Said fifteen cents shall be retained by the justice of the peace as his fee for the issuance of said license and reporting the same and remitting payment therefor to the county treasurer. Such report and remittance shall be made by the justice of the peace within twenty-four hours after the issuance of any license by him; whereupon the county treasurer shall make a record of, and otherwise treat, said license as though it had been issued from his office, except that he shall also note upon his record the name of the justice issuing the license.

Every justice of the peace shall deliver the book or books from which he has issued licenses, together with the stubs therein properly filled out and showing the names of each licensee and the number of the license issued to him, to the county treasurer before the fifteenth day of January of each year.

SEC. 8. Any person becoming the owner, after the fifteenth day of January of any year, of any dog six months old or over which has not already been licensed, or any person owning or keeping a dog which becomes six months old at any time after the fifteenth day of January of any year, shall forthwith apply for and secure a license for such dog in the same manner as the annual license is obtained under the provisions of this act. If any such application is made at any time after the fifteenth day of July of any year the license fee shall be,—for each male or unspayed female dog, one-half of the amount fixed as the annual license, by county commissioners, for male or spayed female dogs; for each unspayed female dog, one-half of the amount fixed as the annual license, by the county commissioners, for unspayed female dogs.

SEC. 9. No license or license tag issued for one dog shall be transferable to another dog, except as provided in sections eleven and twelve of this act. Whenever the ownership or possession of any dog is permanently transferred from one person to another within the same county, the license of such dog may be likewise transferred, upon notice given to the county treasurer. This act does not require the procurement of a new license, or the transfer of a license already secured, when the possession of a dog is temporarily transferred for the purpose of hunting game, or for breeding, trial, or show, in this Commonwealth.

SEC. 10. Whenever any dog licensed in one county is permanently removed to another county, the county treasurer of the county where the license was issued shall, upon the application of the owner or keeper of such dog, certify such license to the treasurer of the county to which the dog is removed. Such treasurers shall thereupon, and upon the payment of a fee of twenty-five cents, issue a license and tag for such dog in the county to which it is removed.

This section does not apply to dogs used during the hunting season for hunting game, or temporarily for breeding, trial, or show, in the Commonwealth; nor for the transportation of dogs for hunting, breeding, trial, or show purposes, the home county license holding good for such purposes throughout the Commonwealth.

Sec. 11. Any person who keeps or operates a kennel may, in lieu of the license for each dog required by this act, apply to the county treasurer for a kennel license entitling him to keep or operate such kennel. Such license shall be issued by the county treasurer, on a form prepared and supplied by the county commissioners, and shall entitle the licensee to keep any number of dogs six months old or over, not at any time exceeding a certain number to be specified in the license. The fee to be paid for each kennel license shall be five dollars for ten dogs or less, and ten dollars for more than ten dogs, permitted to be kept under the kennel license. With each kennel license the county treasurer shall issue a number of metal tags equal to the number of dogs authorized to be kept in the kennel. All such tags shall bear the name of the county issuing it, the number of the kennel license, and shall be readily distinguishable from the individual license tags for the same year.

Sec. 12. The licensee of a kennel shall, at all times, keep one of such tags attached to a collar on each dog six months old or over kept by him under a kennel license. Such tags may be transferred from one dog to another within the kennel whenever any dog is removed from the kennel. No dog bearing a kennel tag shall be permitted to stray or to be taken anywhere outside the limits of the kennel.

This section does not prohibit the taking of dogs having a kennel license outside the limits of the kennel temporarily and in leash, nor does it prohibit the taking of such dogs out of the kennel temporarily for the purpose of hunting, breeding, trial, or show.

Sec. 13. Any person may bring or cause to be brought into the State, for a period of thirty days, one or more dogs for show, trial, or breeding purposes.

Sec. 14. The county treasurer shall keep a record of all dog licenses, and all kennel licenses, and all permits issued during the year. Such record shall contain the name and address of the person to whom each license or permit is issued. In the case of an individual license, the record shall also state the breed, sex, age, color, and markings of the dog licensed; and in the case of a kennel license, it shall state the place where the business is conducted. The record shall be a public record and open to persons interested, during business hours.

Whenever the ownership or possession of any dog licensed under the provisions of this act is transferred from one person to another, except the temporary transfer of dogs for hunting purposes, or for breeding, trial, or show, as provided in section nine of this act, such transfer shall be noted on the record of the county treasurer.

Sec. 15. An accurate record of all license fees collected by the county treasurer, or paid over to him by any justice of the peace, shall be kept as a matter of information; but all such funds shall be turned into the county funds. All moneys at present in the "dog fund" derived from taxation of dogs, under the existing law, shall be turned into the county fund. All bills incurred under this act, or due at the time of the passage of this act, shall be paid out of the county fund, and any excess moneys collected under this act shall be used for other county purposes.

Sec. 16. The assessors for taxation purposes in each township, borough, town, and city of this Commonwealth shall annually, at the time of assessing property as required by law, make diligent inquiry as to the number of dogs owned, harbored, or kept by any person so assessed.

The assessor shall annually, on or before the thirty-first day of December, make a complete report, on a blank form furnished by the county commissioners, to such commissioners, setting forth the name of every owner of any dog or dogs, how many of each sex are by him owned or harbored, and if a kennel is maintained by any person such fact shall also be stated. It shall be the duty of the assessor, at the time of making the assessment, to notify the owner of such dog or dogs that he must obtain a license for the same as provided for in this act; but the neglect or failure so to notify such owner shall not relieve the owner from his duty to obtain such licenses.

Sec. 17. On and after the fifteenth day of January, one thousand nine hundred and eighteen, it shall be unlawful for any person to own or keep any dog six months old or over unless such dog is licensed by the treasurer of the county in which the dog is kept; and unless such dog at all times wears the collar and tag provided for by this act, unless such dogs are temporarily brought into the State for breeding, trial, or show purposes.

SEC. 18. It shall be the duty of every police officer to seize and detain any dog or dogs which bear a proper license tag, and which are found running at large and unaccompanied by its owner or keeper. It shall be the duty of every police officer to kill any dog which does not bear a proper license tag, which is found running at large. The chief of police or his agents, of any city, the high constable of any borough, or the constable of any borough not having a high constable, and the constable of any incorporated town or township, shall cause any dog bearing a proper license tag and so seized and detained to be properly kept and fed, and shall cause immediate notice, either personal or by registered mail, to be given to the person in whose name the license was procured, or his agent, to claim such dog within ten days. The owner of a dog so detained shall pay all reasonable expenses incurred by reason of its detention, under the provisions of this section, before the dog is returned.

SEC. 19. If, after ten days from the giving of such notice, such dog has not been claimed, such chief of police or his agent, constable, or high constable shall dispose of such dog by sale, or by destruction in some humane manner. No dog so caught and detained shall be sold for the purpose of vivisection. All moneys derived from the sale of such dog, after deducting the expense of its detention, shall be paid to the county treasurer and by him placed in the county fund. For services under sections eighteen and nineteen of this act, such officers shall be paid the sum of one dollar for detaining a licensed dog, and the sum of one dollar for the killing of a dog. All expenses incurred under this act or the preceding section, and not otherwise provided for, shall be paid by the proper county.

SEC. 20. For failure to perform his duty under the provisions of this act, such police officer shall be liable to a penalty of two dollars for each offense, which amount shall be deducted from any amount due such police officer from the county, at any settlement between such officer and the county commissioners.

SEC. 21. Any person may kill any dog which he sees in the act of pursuing, worrying, or wounding any live stock, or attacking human beings, whether or not such dog bears the license tag required by the provisions of this act. There shall be no liability on such person in damages or otherwise for such killing.

Any unlicensed dog that enters any field shall constitute a private nuisance, and the owner or tenant of such field, or their agent or servant, may kill such dog while it is in the field, without liability or responsibility of any nature for such killing.

Licensed dogs when accompanied by their owner or handler shall not be included under the provisions of this section, unless caught in the act of worrying, wounding, or killing any live stock, or attacking human beings.

SEC. 22. All dogs are hereby declared to be personal property and subjects of larceny. Except as provided in section twenty-one of this act, it is unlawful for any person, except a police officer, to kill, injure, or poison, or attempt to kill, injure, or poison, any dog which bears a license tag for the current year.

It is unlawful for any person to place any dog-button, or any poison of any description, in any place on his own premises or elsewhere where it may be easily found and eaten by dogs.

It shall be unlawful for any person, except the owner or authorized agent, to remove any license tag from a dog collar, or to remove any collar with a license tag attached thereto, from any dog.

It shall be unlawful for any person to harbor, or permit to remain about his premises, any dog not having a license.

This section does not prohibit the Board of Game Commissioners, or any of its officers and agents, from placing poison, under the provisions of the game laws of this Commonwealth.

SEC. 23. It is unlawful for the owner or keeper of any female dog to permit such female dog to go beyond the premises of such owner or keeper at any time she is in heat, unless such female dog is held properly in leash.

SEC. 24. The owner or keeper of every dog shall at all times, between sunset and sunrise of each day, keep such dog,—either (a) confined within an enclosure from which it can not escape, or (b) firmly secured by means of a collar and chain or other device so that it can not stray beyond the premises on which it is secured, or (c) under the reasonable control of some person, or when engaged in lawful hunting accompanied by an owner or handler.

SEC. 25. Whenever any person sustains any loss or damage to any live stock or poultry by dogs, or any live stock of any person is necessarily destroyed because of having been bitten by a dog, such person, or his agent or attorney, may complain to any township auditor, or to any justice of the peace, magistrate, or alderman of the township, town, borough, or city. Such complaint shall be in writing, shall be signed by the person making such complaint, and shall state when, where, and how such damage was done, and by whose dog or dogs, if known. Such township auditor, justice of the peace, magistrate, or alderman shall at once examine the place where the alleged loss or damage was sustained and the live stock or poultry injured or killed, if practicable. He shall also examine, under oath or affirmation, any witness called before him. After making diligent inquiry in relation to such claim, such township auditor, justice, magistrate, or alderman shall determine whether any damage has been sustained and the amount thereof, and, if possible, who was the owner of the dog or dogs by which such damage was done.

Any owner or keeper of such dog or dogs shall be liable to the owner of such live stock or poultry in a civil action for all damages and costs, or to the county to the extent of the amount of damages paid by such county as hereinafter provided.

Sec. 26. Upon making the examination required in section twenty-five of this act, the township auditor, justice, magistrate, or alderman shall immediately make a certificate thereto, signed and sealed by him, that such appraisement was regularly and duly made. If, by such examination, it appears that any damage has been sustained by the complainant, the township auditor, justice, magistrate, or alderman shall deliver the report of such examination, and all papers relating to the case, to the claimant, or his agent or attorney, upon payment of the costs up to that time. Such report shall be delivered to the county commissioners to be filed in their office.

Sec. 27. Township auditors, justices of the peace, magistrates, and aldermen, for the special service required under sections twenty-five and twenty-six of this act, shall receive two dollars for each case, and five cents per mile for each mile traveled, to be paid by the claimant in each case. In all cases where damages are awarded, the fees paid by claimants shall be included in the amount of such damages.

Sec. 28. Upon the commissioners of the county receiving such report, if it appears thereby that a certain amount of damage has been sustained by the claimant, they shall immediately draw their order on the treasurer of the county in favor of the claimant for the amount of loss or damage such claimant has sustained according to such report, together with necessary and proper costs incurred. Such amount shall be paid by the proper county. No person shall receive any order for any claim until the township auditor, justice of the peace, magistrate, or alderman before whom the claim was made has certified that due diligence was made to ascertain whose dog or dogs did the damage, and that the carcasses of the live stock or poultry killed, and for which damages have been assessed, were buried within twenty-four hours after the assessment of damages. The owners of any live stock or poultry killed by dogs, or live stock necessarily destroyed because of having been bitten by a dog, shall be paid fifty cents each for burial of such live stock or poultry killed, to be paid as other damages under this section. Upon payment by the county of damages to live stock or poultry by dogs, the rights of the owner of such live stock or poultry against the owner of the dog, to the extent of the amount of damages so paid by such county, shall enure to the benefit of the county.

Sec. 29. No payment shall be made for any item which has already been paid by the owner of the dog or dogs doing the injury. The fact that no such payment has been made shall be certified by the township auditor, justice of the peace, magistrate, or alderman.

When any payment is made by the county for any live stock bitten by a dog, such payment shall not exceed one hundred dollars for each horse or mule, forty dollars for each head of cattle, or six dollars for each head of swine.

Sec. 30. Any valid claims or parts thereof for loss or damage to sheep, horses, mules, cattle, or swine, which have accrued under any general or local laws at any time prior to the passage of this act, shall not abate by reason of the repeal of such general or local act, but shall be paid out of the general fund of the proper county.

All claims or parts thereof remaining unpaid for any reason at the close of any year shall not abate, but shall continue as claims until paid in full.

Sec. 31. If, in the report of the township auditor, justice of the peace, magistrate, or alderman, the name of the owner of any dog or dogs having caused loss or damage to any live stock is definitely and conclusively shown, the county commissioners shall notify such owner or keeper immediately to kill said dog or dogs; and if said dog or dogs be killed in accordance with such notice or order, the owner or keeper of said dog or dogs shall be exempt from all further liability.

Upon failure, however, of such owner to comply with such order within a period of ten days, he shall be liable for the damages caused by said dog or dogs; and the chief of police or his agent of the township, town, borough, or city in which said dog or dogs are kept shall, upon notice from the county commissioners, kill such dog or dogs wherever found. For such service he shall be entitled to one dollar for each dog so killed, to be paid by the proper county, upon a certified statement to the commissioners that such dog or dogs have been killed by him. The county commissioners shall issue an order on the county treasurer for such amount, unless payment has been made by the owner or keeper of the dog or dogs. Provided, however, That the owner or keeper of any licensed dog or dogs that have caused loss or damage to poultry shall not be obliged to kill said dog or dogs unless said dog or dogs are mad, but shall be liable for said loss or damage.

Sec. 32. It is unlawful for any person knowingly to make any false statement or to conceal any fact required to be disclosed under any of the provisions of this act.

Sec. 33. In any proceedings under this act the burden of proof of the fact that a dog has been licensed, or has been imported for breeding, trial, or show purposes, or that a dog is under the age of six months, shall be on the owner of such dog.

Any dog not bearing a license tag shall prima facie be deemed to be unlicensed.

Sec. 34. The Secretary of Agriculture, through his officers and agents, shall have the general supervision over the licensing and regulation of dogs and protection of live stock and poultry from damage by dogs in all counties of the Commonwealth. The commissioners of each county shall enforce, within their respective jurisdiction, the provisions of this act. To this end the Secretary of Agriculture may employ all proper means for the enforcement of this act. Any other State department, bureau, or commission may, on request of the Commissioner of Agriculture, assist in the enforcement of the provisions of this act.

Sec. 35. Any person violating, or failing or refusing to comply with, any of the provisions of this act shall be guilty of a misdemeanor, and upon conviction shall be sentenced to pay a fine not exceeding one hundred dollars, or to undergo an imprisonment not exceeding three months, at the discretion of the court.

All fines collected under the provisions of this act shall be forthwith paid to the treasurer of the proper county.

Sec. 36. This act is intended as a complete and uniform system throughout the Commonwealth for the licensing of dogs and the protection of live stock and poultry from injury by dogs; but nothing in this act shall interfere with any law for the protection and preservation of game. Except where such acts or parts of acts are specifically repealed, this act does not repeal or affect any acts or parts of acts relating to mad dogs or dogs affected with any disease.

Sec. 37. Nothing in this act shall be construed to prevent the owner of a licensed dog from recovery, by action at law, the value of any dog which dog has been illegally killed by any police officer, farmer, stockman, or other person within this Commonwealth, from said police officer, farmer, stockman, or other person. In case such police officer or other person fails to pay the value of such dog so killed, the same shall be paid by the proper county. Said value of said dog to be ascertained in the same manner and form as provided in section twenty-five of this act for assessing the damage done to live stock by dogs.

Nothing in this act shall be so construed as to prevent the killing of a dog caught chasing deer at any time of the year, on either public or private lands; or to prevent the killing of dogs by any officer empowered to enforce the game laws of this Commonwealth when said dogs are pursuing game during the closed season for the training of dogs on game, providing said dogs are not under the immediate control or accompanied by their owners or keepers, and also provided that legal notice has previously been given said owner or keeper as required by the game laws of this Commonwealth.

Sec. 38. In the event that any one or more of the provisions of this act should be decided to be unconstitutional, the court's decision holding the same unconstitutional shall not affect the validity of the remaining provisions of this act, it being the intention of the Legislature that the provisions of this act are severable.

SEC. 39. The powers and duties given to and imposed upon county commissioners and other officers by this act shall not extend to cities of the first and second class. In cities of the first and second class the power and duty to fix and collect the license fees provided in section four of this act, and issue license tags, and otherwise perform and carry out the provisions of this act within the limits of such cities shall be, and are hereby, given to and imposed upon the council or councils of each of said cities respectively.

SEC. 40. This act does not repeal or in anywise affect any of the provisions of the following acts:

The act, approved the first day of May, one thousand nine hundred and nine (Pamphlet Laws, three hundred twenty-five), entitled "An act to provide for the protection and preservation of game, game-quadrupeds and game-birds, and song and insectivorous and other wild birds, and prescribing penalties for violation of its several provisions."

The act, approved the fifteenth day of April, one thousand nine hundred and fifteen (Pamphlet Laws, one hundred thirty-three), entitled "An act to amend section twenty-one of an act, entitled 'An act to provide for the protection and preservation of game, game-quadrupeds and game-birds, and song and insectivorous and other wild birds, and prescribing penalties for violation of its several provisions,' approved the first day of May, Anno Domini one thousand nine hundred and nine, by extending the season during which dogs may be trained."

The act, approved the first day of June, one thousand nine hundred and fifteen (Pamphlet Laws, six hundred forty-four), entitled "An act to give additional protection to wild birds and animals and game within the Commonwealth of Pennsylvania; prohibiting the hunting for, or capture or killing, of such wild birds or animals or game by unnaturalized foreign-born residents; forbidding the ownership or possession of dogs by any unnaturalized foreign-born resident within the Commonwealth; and prescribing penalties for violation of its provisions."

SEC. 41. The following acts and parts of acts are hereby repealed:

The act, approved the eighteenth day of May, one thousand eight hundred and seventy-eight (Pamphlet Laws, seventy-two), entitled, "An act extending the provisions of an act relating to dogs in Allegheny, Chester, Northampton, Schuylkill and Lancaster Counties, approved the sixth day of April, Anno Domini one thousand eight hundred and fifty-four, to all the counties of this Commonwealth."

The act, approved the twelfth day of June, one thousand eight hundred and seventy-eight (Pamphlet Laws, one hundred ninety-eight, number two hundred thirty-one), entitled "An act for the taxation of dogs and the protection of sheep."

The act, approved the fifteenth day of May, one thousand eight hundred and eighty-nine (Pamphlet Laws, two hundred twenty-two), entitled "An act for the taxation of dogs and the protection of sheep."

The act, approved the twenty-fifth day of May, one thousand eight hundred and ninety-three (Pamphlet Laws, one hundred thirty-six), entitled "An act for the taxation of dogs and the protection of sheep."

The act, approved the seventh day of June, one thousand eight hundred and ninety-seven (Pamphlet Laws, one hundred thirty, number one hundred five), entitled "A supplemental to 'An act for the taxation of dogs and the protection of sheep,' approved the twenty-fifth day of May, Anno Domini one thousand eight hundred and ninety-three, providing for the payment of claims which have accrued under local laws."

The act, approved the eleventh day of April, one thousand nine hundred and one (Pamphlet Laws, seventy-three, number forty-three), entitled "A supplement to an act, entitled 'An act for the taxation of dogs and the protection of sheep,' approved the twenty-fifth day of May, Anno Domini one thousand eight hundred and ninety-three, providing that the fund raised by the taxation of dogs be applied, in addition to the loss of sheep, for the loss of other domestic animals bitten by mad dogs."

The act, approved the twenty-third day of April, one thousand nine hundred and one (Pamphlet Laws, ninety-two), entitled "An act to amend the ninth section of an act, entitled 'An act for the taxation of dogs and the protection of sheep,' approved the twenty-fifth day of May, one thousand eight hundred and ninety-three."

The act, approved the first day of March, one thousand nine hundred and five (Pamphlet Laws, twenty-eight), entitled "An act to amend the fifth section of an act, entitled 'An act for the taxation of dogs and the protection of sheep,' approved the twenty-fifth day of May, Anno Domini one thousand eight hundred and ninety-three, by requiring proof of the burial of the carcasses of sheep killed by dogs."

The act, approved the first day of June, one thousand nine hundred and seven (Pamphlet Laws, three hundred sixty-two), entitled "An act supplementary to 'An act for the taxation of dogs and the protection of sheep,' approved the twenty-fifth day of May, Anno Domini one thousand eight hundred and ninety-three; requiring all dogs to wear a collar to be provided by the owner, together with a tag to be attached thereto showing payment of tax; imposing certain duties upon constables, tax collectors, and county commissioners; and providing for the killing of dogs whose owners fail to comply with this act and the act to which this is a supplement."

The act, approved the twenty-third day of April, one thousand nine hundred and nine (Pamphlet Laws, one hundred seventy), entitled "An act to amend the tenth section of an act, entitled 'An act for the taxation of dogs and the protection of sheep,' approved the twenty-fifth day of May, Anno Domini one thousand eight hundred and ninety-three, by making the act applicable to counties having over one hundred and fifty thousand, and less than two hundred and fifty thousand inhabitants."

The act, approved the fifteenth day of June, one thousand nine hundred and eleven (Phamphlet Laws, nine hundred sixty-eight), entitled "An act supplementary to 'An act for the taxation of dogs and the protection of sheep,' approved the twenty-fifth day of May, Anno Domini one thousand eight hundred and ninety-three; requiring all dogs to wear a collar to be provided by the owner, together with a tag to be attached thereto showing payment of tax, said tag to be provided by the county commissioners; imposing certain duties upon constables, tax collectors, and county commissioners; and providing for the killing of dogs whose owners fail to comply with this act and the act to which this is a supplement; and providing penalties for failure to comply with the provisions of this act."

The act, approved the twentieth day of May, one thousand nine hundred and thirteen (Pamphlet Laws, two hundred fifty-nine), entitled "An act to amend the first and third section of an act, approved the fifteenth day of June, one thousand nine hundred eleven, entitled 'An act supplementary to "An act for the taxation of dogs and the protection of sheep," approved the twenty-fifth day of May, Anno Domini one thousand eight hundred and ninety-three; requiring all dogs to wear a collar to be provided by the owner, together with a tag to be attached thereto showing payment of tax, said tag to be provided by the county commissioners; imposing certain duties upon constables, tax collectors, and county commissioners; and providing for the killing of dogs whose owners fail to comply with this act and the act to which this is a supplement; and providing penalties for failure to comply with the provisions of this act,' by making its provisions apply to all dogs of four months old and upwards; and to provide that the payment of the proper tax, and the giving of a tag by the collector, shall be sufficient assessment for all purposes."

The act, approved the third day of June, one thousand nine hundred and fifteen (Pamphlet Laws, seven hundred ninety, number three hundred fifty), entitled "An act for the protection of sheep and the incidental destruction of certain dogs."

The act, approved the third day of June, one thousand nine hundred and fifteen (Pamphlet Laws, seven hundred ninety-one), entitled "An act amending an act, entitled 'An act supplementary to "An act for the taxation of dogs and the protection of sheep," approved the twenty-fifth day of May, Anno Domini one thousand eight hundred and ninety-three; requiring all dogs to wear a collar to be provided by the owner, together with a tag to be attached thereto showing payment of tax, said tag to be provided by the county commissioners; imposing certain duties upon constables, tax collectors, and county commissioners; and providing for the killing of dogs whose owners fail to comply with this act and the act to which this is a supplement, and providing penalties for failure to comply with the provisions of this act,' approved the fifteenth day of June, one thousand nine hundred eleven, as amended, so that assessors of the several cities, wards, boroughs, townships, or other assessment districts of this Commonwealth, shall collect an annual license fee for said dogs at the time of the annual assessment and issue a receipt and tag therefor; providing for the publication of the assessor's list of licensed dogs; requiring that all unlicensed dogs be killed, and fixing penalties for the violation of this act."

The act, approved the twenty-fourth day of April, one thousand nine hundred and three (Pamphlet Laws, two hundred ninety-six), entitled "An act to amend section one hundred and fifty-four of the act of March twenty-one, one thousand eight hundred and sixty, entitled 'An act to consolidate, revise, and amend the penal laws of this Commonwealth,' " is hereby repealed in so far as it relates to dogs.

Section 42. All other acts or parts of acts, general, local, or special, inconsistent with or supplied by this act, are hereby repealed.

THE DOG LAW OF WEST VIRGINIA.

Enacted May 25, 1917. Effective 60 days from passage.

AN ACT relating to the protection of sheep and the conservation of the food supply necessary for the maintenance of the people.

SECTION 1. It shall be unlawful for any person to suffer or permit any dog in his possession or kept by him about his premises, to run at large on any unenclosed land, or trespass upon any enclosed or unenclosed lands of another.

If any dog be suffered or permitted to run at large or trespass as aforesaid, or kill or assist in killing, injuring, or chasing any sheep or other domestic animals out of the enclosure of the owner or keeper of such dog, proof that such dog was at large at the time and place of injury complained of shall be prima facie evidence of liability and guilt, as hereinafter provided.

SEC. 2. The county court of every county and the council of every municipality, shall prepare and deliver to its assessor, sheriff, constables, or other police officers, consecutively numbered substantial aluminum or brass tags, bearing the calendar year and the name of the county or municipality issuing such tag which shall be delivered by them to any citizen of the county or municipality who may apply therefor and pay into its treasury a fee of not more than twenty-five cents for each tag, which tags shall be fastened upon the collars worn by the dogs owned or kept by such citizens, and for which fee such officer shall issue a receipt showing the name and address of the citizen and the year and number of the tag. Such officer shall also keep a record book showing the name and address of each citizen to whom such tags are issued, the number of such tag so issued and the year thereof.

Any citizen may, and the sheriff, constables or other police officers of any county, district or municipality, shall seize any dog found unaccompanied by its owner or keeper and running at large on any road, street or other public place, or trespassing on any premises other than the premises of the owner. If such dog is wearing a collar bearing such tag, it shall be impounded and the citizen or officer so seizing and impounding said dog shall immediately thereafter by written notice notify the owner of such dog as disclosed by the records herein provided for to be kept that such dog has been seized and impounded by him and unless such owner or keeper of such dog shall, within seven days from the receipt of said notice claim such dog, and pay such citizen or officer a fee of two dollars for seizing, and a fee of ten cents for each day it is impounded, it shall be killed forthwith in any humane manner. Provided, that any citizen or officer may kill any dangerous or vicious dog, or any dog not registered as herein provided for, or any dog permitted to run at large after the owner or keeper shall have had notice not to permit such dog to run at large, if such dog be off the premises and out of the control of its owner or keeper. No citizen or officer shall be liable in damages or to prosecution by reason of killing any dog as herein provided. For every dog seized and not claimed by its owner or keeper as aforesaid, the county court shall pay the citizen or officer entitled thereto said fees and costs upon due proof of the seizure, impounding and killing of such dog; and the owner or keeper shall be liable therefor in any action before the court or justice having jurisdiction; provided, further, that it shall be the duty of the common council of every incorporated city, town or village in this state, to provide a suitable pound for such dog or dogs so seized under the provisions of this act.

SEC. 3. It shall be unlawful for any unnaturalized foreign-born resident of this state to own or keep a dog of any kind in this state.

SEC. 4. Nothing in this act shall be construed to prevent any citizen of this state from lawfully hunting with a dog or dogs on any land owned by him or by any person from whom such citizen has first secured permission to hunt with a dog or dogs; and no citizen shall hunt with a dog or dogs upon the land of another without written or verbal permission from the owner or lessee thereof.

SEC. 5. Any person violating any provision of this act or failing or neglecting to perform any duty imposed by it, shall be liable, in an action or prosecution before any court or justice having jurisdiction, for the amount of damage sustained, and also for a fine of not less than five or more than one hundred dollars and the cost of prosecution, or to imprisonment in the county jail not more than thirty days, or to both fine and imprisonment; and any person who shall remove from any dog a collar bearing a tag as provided for in this act, or who shall alter or remove any such tag from a dog properly registered as herein provided for shall be guilty of a misdemeanor. and, upon conviction shall be fined not to exceed five or more than one hundred dollars and the cost of the prosecution, or to imprisonment in the county jail not more than thirty days, or to both fine and imprisonment and shall be liable to the owner or keeper of such dog in a civil action for the amount of damages sustained.

SEC. 6. All acts and parts of acts inconsistent herewith are hereby repealed.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO SHEEP RAISING.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Breeds of Sheep for the Farm. (Farmers' Bulletin 576.)
Sheep Scab. (Farmers' Bulletin 713.)
The Sheep Tick and Its Eradication by Dipping. (Farmers' Bulletin 798.)
Equipment for Farm Sheep Raising. (Farmers' Bulletin 810.)
Farm Sheep Raising for Beginners. (Farmers' Bulletin 840.)

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THE CITY AND SUBURBAN VEGETABLE GARDEN

H. M. CONOLLY

Assistant Horticulturist in Agricultural Education

A Typical City Garden

FARMERS' BULLETIN 936

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

and the

States Relations Service
A. C. TRUE, Chief

Washington, D. C. February, 1918

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THIS BULLETIN is intended primarily to show the importance of gardening in city and suburban districts and to encourage greater efforts in these sections.

City gardening in back yards and vacant lots may be made the source of considerable profit and furnishes healthful exercise for the members of the family.

Gardening under the conditions that exist in cities and towns is essentially different from gardening in the country, in that city people as a rule are not experienced in the art of growing plants.

Proper organization and instruction are essential to get the most out of city gardening. In the following pages suggestions are given for conducting the work of organization, as well as directions covering the preparation of the soil, the starting of plants, and the cultivation and care of all the more important garden crops.

THE CITY AND SUBURBAN VEGETABLE GARDEN.

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IMPORTANCE OF CITY GARDENS.

A WELL-PLANNED and carefully tended garden is one of the most pleasant and satisfying pieces of work in which the city or suburban family can utilize its spare time. If the soil is properly prepared and a little attention is given the garden as required, the work need not become a burden on the members of the household.

Gardening the back yards and vacant lots of the cities and towns of our country is a worthy endeavor, because it utilizes the spare

FIG. 1.—A group of vegetables harvested at one time from a home garden.

time and labor of persons employed at other work and brings to the family table a greater diversity of food. (Fig. 1.) It also eliminates many undesirable views and eyesores, putting in their places pleasing green growing crops. (Figs. 2 and 3 and title-page illustration.)

Gardening is a patriotic work which will result in both pleasure and profit. It gives pleasure not only in the work with the growing plants, but in the producing of high-quality, crisp, fresh vegetables for the family table. It gives profit by producing vegetables cheaper than they can be purchased and by reducing the need for more expensive foods. (Fig. 4.) Gardening is profitable also because better health is secured by the exercise in the open air and the use of more vegetables in the diet.

Gardening should be an important part of the city and suburban life because of the interest it adds to the lives of people little used to country surroundings. It is interesting to the young and the old, and to women and girls as well as men and boys. There is no better way to keep the boys off the streets and out of mischief than to give them a plat of ground on which they can make a garden (figs. 5 and 6), the results to be their very own. Very young children (fig. 7) can be interested in garden work. One 5-year-old boy in Washington, D. C., this past season planted several kinds of seed and grew the plants to maturity. This youngster could be sent to the garden for any one of half a dozen different vegetables and would return with the right one.

FIG. 2.—A city lot which may be used for a garden.

TYPES OF GARDENING.

There are several types of gardening which should be of interest in all city and suburban sections. Some of the more important types are back-yard gardens, vacant-lot gardens, and school gardens.

The back-yard garden is probably the most important of the three, because it is more intimately associated with the home. The area immediately back of the house is the plat usually considered as the back-yard garden. If this spot is not used as a garden it often becomes an unsightly place, and thus gardening improves the home surroundings. (Figs. 8 and 9.)

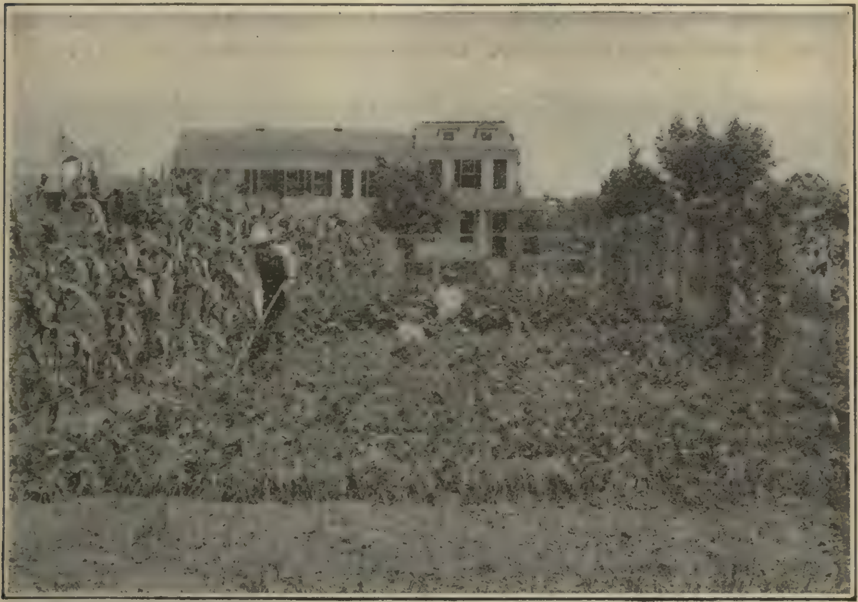

FIG. 3.—A vacant lot the first season after the rubbish had been cleared away and a garden established.

The condition of the soil in the back yard can be steadily improved year after year as long as the family occupies the house. (Fig. 10.) Its nearness to the house is a great inducement for the family to work the garden and to utilize the crops to the fullest extent.

Vacant-lot gardens are important because of the large areas that can be found for the work.

Commercial truck growers or market gardeners utilize land in the outskirts of cities, but unless this land is very productive or can be had at a low rental for a period of years it will not pay them to lease it. With the use of the home gardener's labor, however, the cropping of these areas can be made remunerative.

Large areas of vacant land may be taken over by a company or organization and divided into a number of small plats which individuals may tend. In some cases large plats have been used as gardens by a number of individuals who shared equally in the labor, expense, and results. This type of community garden is not usually a success unless it can be done by a school or institution which controls all of the work. Figure 11 shows a large area which has been divided into a number of individual gardens, while figure 12 shows a large area used as a garden by a public institution.

School gardens are important because they bring to the child early in life an opportunity to see how plants grow, to identify the kinds of plants that are found in the garden, and to learn some of the economic phases of gardening as applied to the family food supply. (Fig. 13.)

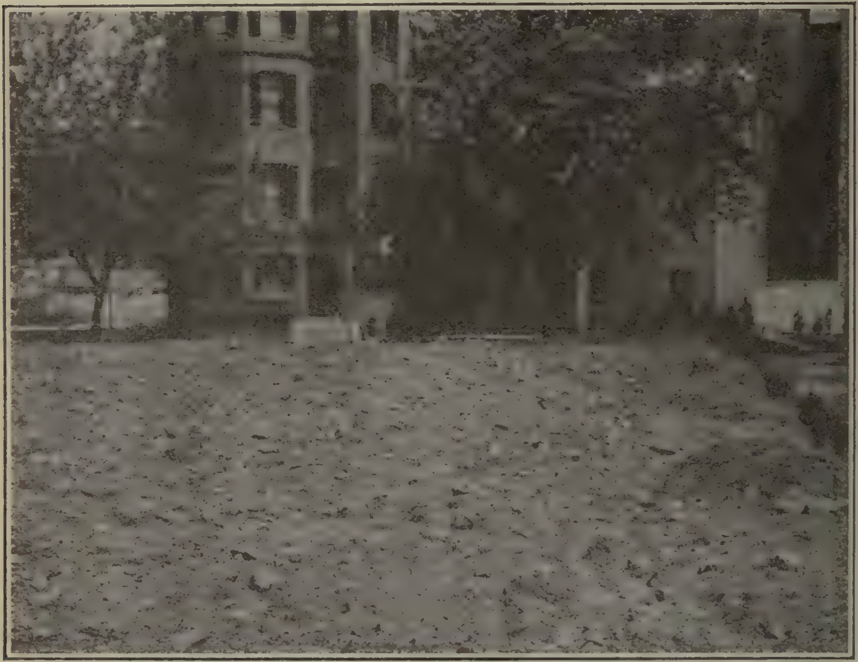

FIG. 4.—A vacant lot after plowing. Four women removed the stones and trash from this plat, planted garden crops, and produced enough vegetables for their families.

Porch and window gardens are not important, but in some of the thickly populated sections of the larger cities this type of gardening is quite often practiced. Window boxes, boxes at the ends of porches or on shed roofs, boxes on the edges of walks or even on the small front lawn, and boxes and barrels on the roofs of tenement and apartment buildings are some of the ways of utilizing small spaces in the growing of plants. In the limited areas of boxes, barrels, etc. (figs. 14 and 15), no large quantity of food can be produced, but the growing of plants can be made an interesting study, besides adding something to the family table. Lettuce, parsley, radishes, onions, and tomatoes are some of the crops best suited for such limited spaces.

Both boys' and girls' clubs and adult clubs may utilize vacant lots or the home back yards. There are a number of kinds of clubs besides regular garden clubs which have accomplished wonderful results in garden work. (Fig. 16.) Boy-scout troops, girl-scout troops, woodcraft clubs, and other similar organizations are among this class of clubs.

COST AND VALUE OF CROPS FROM HOME GARDENS.

There is a great lack of uniformity in figures collected on the value of garden crops. Prices vary from day to day and also vary in different sections of a city. Some persons figure the value of their garden products at the highest retail prices; others at wholesale prices. Many children obtain prices for their garden products much greater than market prices.

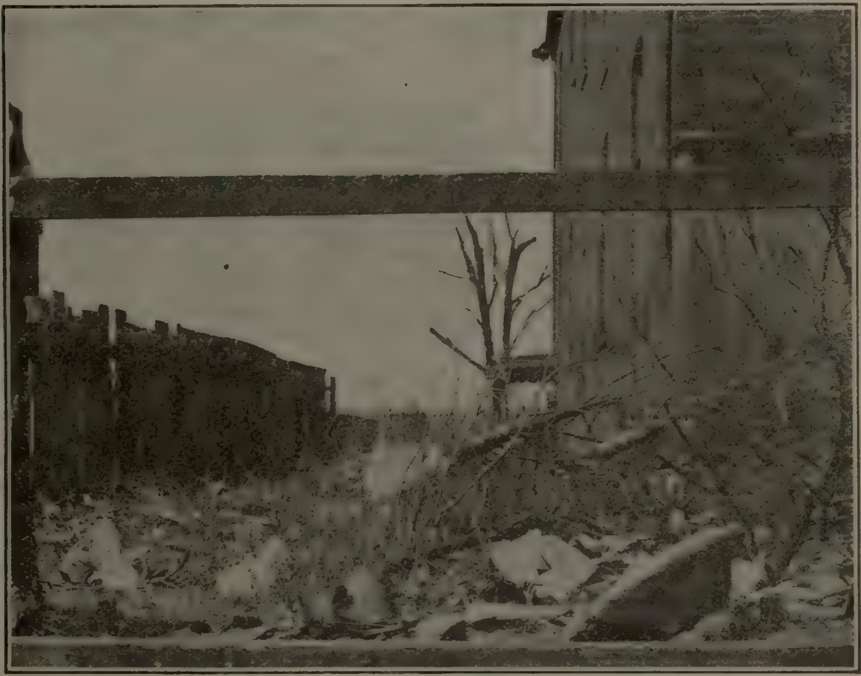

FIG. 5.—A lot covered with rubbish. Enthusiasm and labor were required to make this plat into a garden.

To give uniformity to the value of garden vegetables, a scale of prices should be established for the city, and all who make records of their gardens should use as a guide the scale set for their city.

The following items of cost and valuation of garden products are offered as suggestions to those interested in gardening campaigns.

Cost of fertilizer, labor, tools, seeds, plants, and spraying material.

(*a*) Fertilizers: Charge manure at $2.50 per 1½ cubic yards or 2-horse load. This would be equal to two 1-horse loads. Commercial fertilizer and lime should be charged at cost price.

(*b*) Labor: Include all expense of labor hired.
(*c*) Tools: Charge at one-fourth the first cost when new.
(*d*) Seeds: All seeds should be charged at prices at store, whether saved, kept over, or given to you.
(*e*) Plants: Charge at market prices.
(*f*) Spraying material: Charge at cost price.

Value of crops.

The value of crops should be figured at the prices given below if of good quality; if not of good quality, reduce the value accordingly. If of extra size and quality or extra early, increase the value.

Beans, Lima (shelled beans), 25 cents per quart.
Beans, snap, 30 cents per peck.
Beets, 50 cents per peck. (50 beets of medium size.)
Cabbages, 5 cents per head.
Cauliflower, 10 cents per head; large, high quality, up to 20 cents.
Carrots, 50 cents per peck. (80 carrots of medium size.)
Celery, 4 cents per stalk.
Sweet corn, 2 cents per ear.
Cucumbers, 2 cents each for large and 50 cents per peck for small pickles.
Eggplants, 5 cents each.
Lettuce, 5 cents per head, or an equal quantity of leaf lettuce.
Muskmelons, 10 cents each.
Onions, 35 cents per peck, dry; 20 cents per quart, for sets; 5 cents a bunch if green.
Parsnips, 40 cents per peck.
Peas, 40 cents per peck.
Peppers, 10 cents per dozen.
Irish potatoes:
  Early, 35 cents per peck.
  Late, 25 cents per peck.
Radishes, 3 cents per bunch.
Salsify, 50 cents per peck.
Spinach, kale, turnip greens, beet greens, mustard, etc., 25 cents per peck.
Squashes:
  Summer, 50 cents per dozen.
  Late, 25 cents each.
Tomatoes:
  Early, 50 cents per peck.
  Main crop, 25 cents per peck.
Turnips, 25 cents per peck.
Watermelons, 25 cents each.

LABOR AND EXPENSE REQUIRED TO MAKE HOME GARDENS.

Persons interested in making a garden often ask how much labor it will take to care properly for a garden of a certain size, and what results should be expected under average conditions.

The following records secured in the District of Columbia are thoroughly reliable and vouched for by the school teachers and leaders who supervised part of the work and by the agricultural agent for the District:

(1) Records from 20 school boys' and girls' home gardens, each of which comprised an area of 500 square feet or more.

Average area per garden, 1,022 square feet.
Average expense per garden, $1.38.
Average hours of labor per garden, 17.

(2) Records from 59 school boys' and girls' home gardens, each of which comprised an area less than 500 square feet.

Average area per garden, 166 square feet.
Average expense per garden, 62 cents.
Average hours of labor per garden, 14.

(3) Records from 8 club boys' and girls' home gardens, each of which comprised an area more than 500 square feet.

Average area per garden, 1,909 square feet.
Average expense per garden, $2.51.
Average hours of labor per garden, 39.

(4) Records from 12 club boys' and girls' home gardens, each of which comprised an area less than 500 square feet.

Average area per garden, 305 square feet.
Average expense per garden, 84 cents.
Average hours of labor per garden, 28.

(5) Records from 50 family home gardens, which comprised areas ranging from 720 to 65,340 square feet.

Average area per garden, 7,801 square feet.
Average expense per garden, $13.92.
Average hours of labor per garden, 132.

From the above records from 149 home gardens, a garden averaging 2,800 square feet will cost $4.82 and will require about 58 hours of labor to take care of it during the season.

The figures in the following table are taken from the records referred to above.

Value of vegetables which a home garden will produce.

Kind of garden.	Number.	Average per garden.				Value per square foot.		Value per acre.	
		Area.	Expense.	Value.	Hours of work.	Gross.	Net.	Gross.	Net.
Boys' and girls' home school gardens:									
More than 500 square feet in area	20	*Sq. ft.* 1,022	$1.38	$7.50	17	$0.00734	$0.006	$319.73	$261.36
Less than 500 square feet in area	59	166	.62	2.97	14	.018	.0142	784.08	618.55
Boys' and girls' club gardens:									
More than 500 square feet in area	8	1,909	2.51	14.46	39	.0122	.0092	531.43	400.75
Less than 500 square feet in area	12	305	.84	6.95	28	.0226	.0197	984.46	858.13
Family home gardens:									
Ranging from 720 to 65,340 square feet	50	7,801	13.92	70.56	132	.00904	.00726	393.78	316.25
Best garden of large extent	1	8,800	25.00	231.82	200	.0263	.0236	1,194.98	1,067.22
Best garden of small extent	1	272	.85	9.05	17½	.033	.03	1,437.48	1,306.80

The figures in this table show that the average net value per acre is considerably greater in the gardens of 500 square feet or less than in larger areas. This is shown both in the case of the boys' and girls' home school gardens and in the boys' and girls' home club gardens.

Another convincing point the figures make is that the club gardens produced very much better returns than the home school gardens or the home family gardens. This difference is due, no doubt, to the better supervision given to the club gardens and the greater stimulation due to healthy competition among the members.

LOCATION AND SOIL.

If no yard is available, a suitable vacant lot may be secured. In every case the garden should be near the house, so that it will be possible for the housewife to go into the garden and in a few minutes secure the desired vegetables. When the garden is situated at some distance from the house the effort necessary to care for it becomes a burden, the products are not utilized to the fullest extent, and the garden is soon neglected.

Areas shaded a large portion of the time should not be selected for a garden. (Fig. 17.) The foliage crops, such as lettuce, parsley, and chard, will thrive fairly well when they get three or four hours of sunlight a day. Such crops as tomatoes, eggplants, and peppers

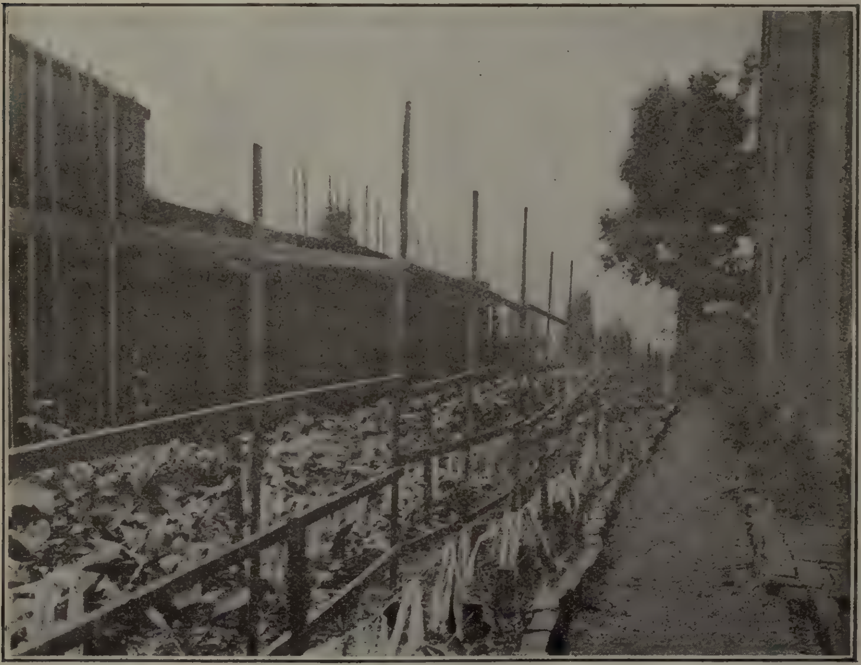

FIG. 6.—The same plat illustrated in figure 5, showing a very profitable vegetable garden maintained by boys assisted by their parents.

FIG. 7.—An example of how children may be interested in garden work. This 3-year-old youngster has spent many hours in the garden and can name many of the matured crops.

should have an abundance of sunshine, at least five or six hours each day. (Fig. 18.)

Most city gardeners are handicapped in that they must make the best of the space and soil available to them. While a sandy loam with a well-drained southern exposure will give better results than less favored locations, the gardener should not be deterred from making an effort even though his location is not the best.

Almost any kind of soil, unless it is composed of bricks, mortar, stone, rubbish, etc., can be used for gardening if it is properly handled. Heavy clay soils may be improved greatly by adding large quantities of strawy manure in the fall or by turning under green-manure crops. It is usually practicable to cover the clay soil with 2 or 3 inches of sifted coal ashes and then thoroughly incorporate the two by spading and hoeing. Sandy soils may be decidedly improved for gardening purposes by growing green-manure crops on the land or by turning under liberal quantities of stable manure.

Good drainage is very important in the garden, and if the soil is not naturally well drained it should be drained artificially. Tile drains are most satisfactory for the garden, but open ditches may be used.

SIZE OF THE GARDEN.

The city back yard is seldom large enough to produce sufficient vegetables for the average family. On limited areas of 800 square feet or less, only such crops as lettuce, snap beans, onions, radishes, a few tomato plants, spinach, kale, chard, beets, and other crops requiring little space should be grown. (Fig. 19.) Where more space is available, a quarter acre may be profitably employed, and where sweet corn and sweet and Irish potatoes are to be grown a half acre is none too much. (Fig. 20.) The keynote to success in the garden is to have the soil as fertile as possible, so as to produce sufficient vegetables with the least amount of labor.

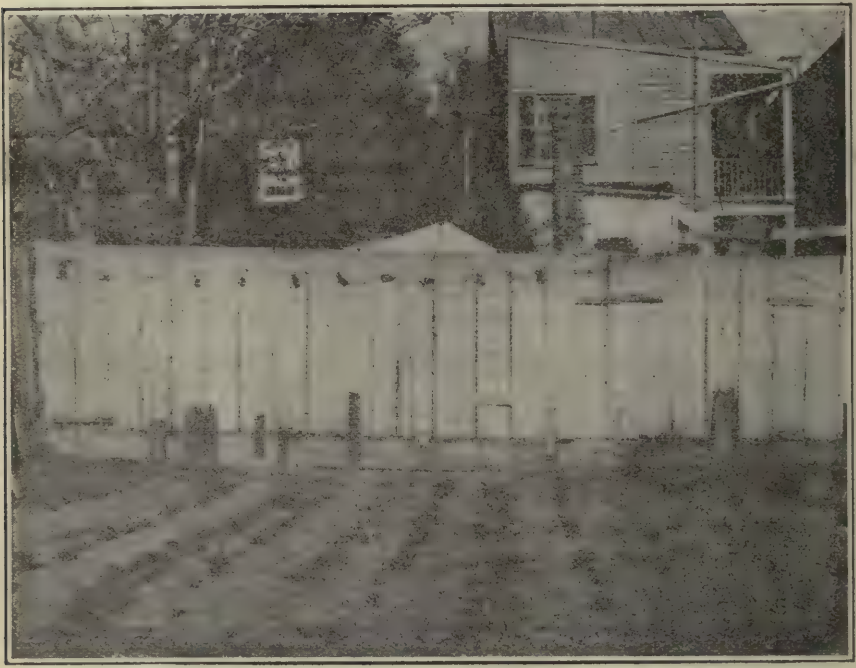

FIG. 8.—A back yard after being cleaned up and planted to early Irish potatoes.

A small garden well cared for is far better than a larger garden which is neglected.

ARRANGEMENT OF THE GARDEN.

The arrangement of the garden should be carefully worked out to suit the conditions of each particular garden. In the winter, when there is usually plenty of time available, it is a good plan to sit down with paper, pencil, and rule and draw up a plan of the garden. Mark on this plan the location for each vegetable and the area covered, the successions, date of planting, etc. By making a plan and following it throughout the season the greatest success will be had with the garden.

While each garden must be planned to suit the conditions, there are a few general rules which apply to all gardens. The rows should run north and south, to give the best distribution of sunlight on all sides of the plants, but where it is more convenient, and where washing must be prevented, the rows can run in other directions. All permanent vegetables, such as rhubarb, asparagus, and herbs, should be planted at one side of the garden, where they will not be disturbed every year. Tall vegetables, like corn and pole beans, should be put in a position where they will not shade the small vegetables. Wherever the land is available and horse cultivation can be used, allow sufficient space between rows for the larger cultivating tools. Also run the rows the long way of the garden in order to avoid excessive turning at the ends of the rows. (Fig. 21.) For horse cultivation provide a 4 or 5 foot pathway along two sides of the garden at right angles to the rows, so that turning with the cultivator can be managed without injuring the vegetables. All vegetables that are to be planted early and that require early cultivation should be grouped at one side of the garden, to facilitate cultivation. Figure 22 may offer many suggestions as to the arrangement and location of the crops in a quarter-acre garden. The distances given for rows are for horse cultivation.

FIG. 9.—The same area shown in figure 8 later in the season. Beans, chard, and cabbages have followed the potatoes, and Lima beans have covered the board fence.

FENCES AND WINDBREAKS.

Every garden should be surrounded by a fence to keep out stray dogs, cats, chickens, and small children. In the prairie regions a windbreak or shelter belt is absolutely necessary to protect the garden, and in other regions, while not so necessary, a windbreak may protect the crops from damage by strong winds, and the protection from cold winds may lengthen the crop-growing season considerably. If buildings, a grove of trees, a row of evergreens, or a hedge are not available as a windbreak, a tight board fence may be erected, which will serve the double purpose of a fence and a windbreak.

SUCCESSION OF CROPS.

To make a garden yield the maximum quantity of vegetables it is necessary that the land be occupied as much of the time as possible. In some sections three or more crops may be grown on the same land during the season. (Fig. 23.) Care must be used in selecting the crops that are to follow the early-season crops. The vegetable used for the first planting, or one with the same characters or belonging to the same family, should not be used in the same place at the second planting. Cabbage, kale, mustard, Brussels sprouts, and

FIG. 10.—A portion of a prize-winning garden in Washington, D. C. This garden soil has been improved every year for a period of five years. The value of the crop in 1917 was at the rate of $1,149.98 per acre on an area of 8,800 square feet.

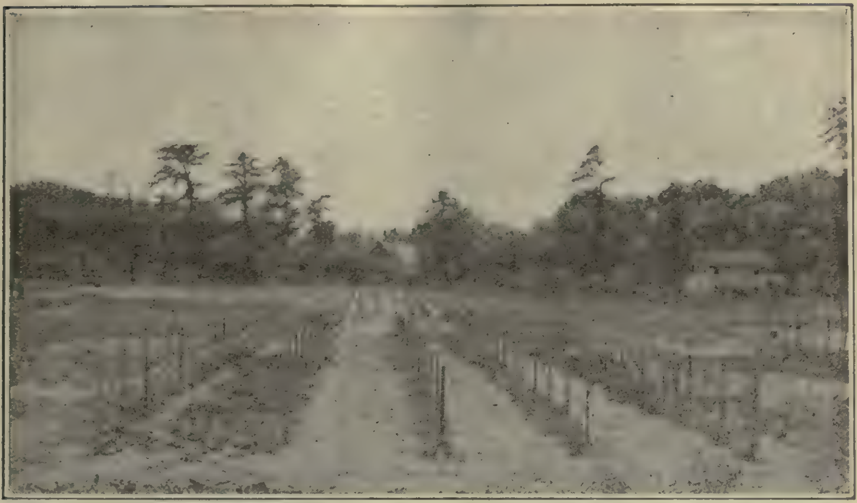

FIG. 11.—A portion of a large field which has been divided into a number of individual gardens. Each garden is 25 by 40 feet. The plat in the foreground was planted entirely to tomatoes. Many such fields may be plowed and put under cultivation as vegetable gardens.

cauliflower should not follow each other, for the same insects and diseases affect all these plants; and for the same reason peppers, eggplants, and tomatoes should not follow each other. In many cases, especially in the more southern sections of the country, after an early vegetable is harvested, if no other vegetable is to be planted until autumn, the ground may be planted with cowpeas or some other leguminous crop which can be turned under in preparing for the fall crop.

ROTATIONS.

The rotation of crops is very important in the garden, both in conserving plant food and in checking the spread of insects and diseases. Space which has been occupied by a diseased crop should not be replanted the following year with the same or a closely related crop. It is a good plan to rotate the entire garden every year with an equal-sized plat which has been planted to clover or cowpeas. (Fig. 24.) If such an extra plat is not available, the locations of the various vegetables may be changed each succeeding year. Following root crops, such as parsnips, beets, and carrots, with foliage crops, like kale, cabbage, collards, and lettuce, or with crops like tomatoes, beans, melons, or peppers, will tend to conserve the plant food in the soil and prevent heavy infestations of insects and plant diseases.

SEED.

As soon as the location for the garden is selected and a plan made showing the kinds of vegetables to be grown and the places for planting them, the question of varieties should be decided. A number of points should be considered in selecting the varieties to grow, among them being the time of maturity, the adaptation of the variety to the local conditions, and the quality of the vegetable produced. Usually it is better to select only standard varieties that do well in the locality, but a few novelties may be tried in a small way. With the exception of tomatoes and corn it is often better to select a few varieties and plant these in succession than to procure a larger number of early and late varieties.

Vegetable seed should be purchased several weeks ahead of the time it is to be used, and it is advisable to procure the seed only from reliable seedsmen. A good plan is to procure several descriptive catalogues either from reliable local seedsmen or from other good seed houses. These catalogues should be secured in the winter, so that the selection of seed may be made at leisure moments and the order sent out early.

FIG. 12.—An area devoted to vegetables at an industrial school for girls.

The quantity of seed to purchase will depend upon the preferences for different vegetables and the size of the garden. The table on page 28 gives the amount of seed necessary for a 50-foot row of the various garden crops.

Buy only first-class seed, for inferior seed will be expensive at any price. Buy only the quantity of seed actually needed for your garden. To buy more may deprive another of a garden.

Seed which has been left from the preceding season should be tested by counting out 25 to 50 seeds of each variety, putting them in a plate between two sheets of moist cloth or blotting paper, and covering with another plate. By looking at the seed every day, the promptness and percentage of germination can be ascertained. Good grades of most garden seeds should germinate 60 to 85 per cent in five or six days. Seeds that send out strong sprouts in a few days have the vitality necessary to insure a good stand of plants, and this is an important item in garden work.

PLANTS.

Plants for the garden can be grown in a limited way in shallow boxes or flats set in a sunny window of the dwelling house. (Fig. 25.) The soil for the seed boxes should be fine and mellow, and the seed should be planted in rows, with a label to designate each variety or kind. As soon as the plants form three or four leaves they should be transplanted into other boxes, the plants being set at least 2 inches apart each way. Where there is not sufficient space in the house for growing all the plants desired, it is possible to grow the seedlings inside and transplant them into a coldframe out of doors.

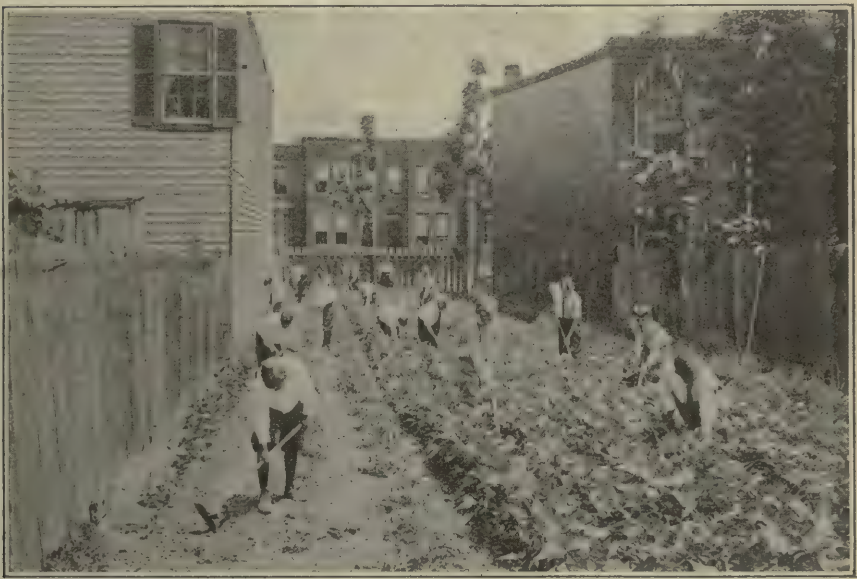

FIG. 13.—A city lot made into a school garden. The children work the garden under the supervision of the teacher. This garden during the season of 1917 produced vegetables to the value of $125.

All seedlings grown in boxes or flats should be transplanted at least once before they are ready to set in the garden. This transplanting causes the plant to become stocky and to produce a mass of fine roots. (Fig. 26.) In many cases the seedlings are transplanted from the seed flats into earthen pots or dirt bands. Plants from the pots or bands can be set in the garden without disturbing the roots, and the plants receive no check in their growth. By this means it is possible to have plants ready to set in the garden at any time when another crop is taken out. For example, as fast as early cabbages are cut, tomato plants can be set in their places, and pepper plants may be set in the row as fast as the early lettuce is harvested, etc.

HOTBEDS AND COLDFRAMES.

A hotbed and a coldframe of some form are very necessary to secure the maximum benefits from the garden. Plants can be raised more satisfactorily and on a much larger scale with frames than with seed boxes set in the house window. The frames can also be used for maturing early crops and for carrying over crops into the winter.

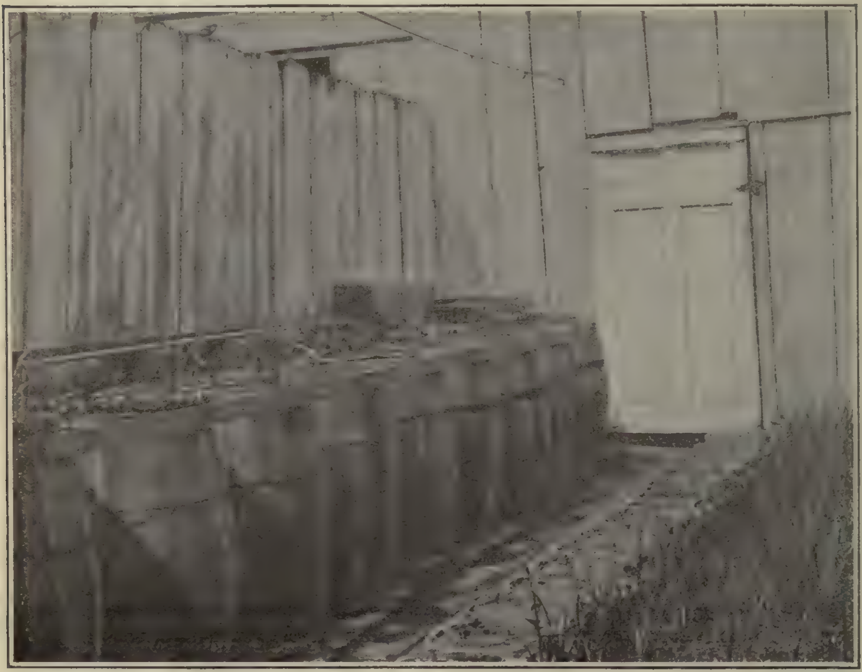

FIG. 14.—Barrels utilized for growing vegetables. These were filled two-thirds full of ashes, and a foot of soil on top was supplied by a gardener who had time and energy to devote to a very limited area in a congested section of Washington, D. C.

A very serviceable frame for a hotbed or coldframe may be constructed like the one shown in figure 27. Oak or cypress boards 1 inch thick may be used. A more permanent frame can be constructed by using concrete. A hotbed 6 by 6 feet will be sufficient for the needs of most home gardens, and a coldframe of equal size will be found of great assistance in growing crops successfully.

MAKING A HOTBED.

To make a hotbed, secure a quantity of fresh horse manure, consisting of about two parts of the solid excrement to one part of litter. Pile in a heap under cover for a few days, so that it will heat, and turn it over a few times to mix it thoroughly. When mixed, place the manure in a pile to a depth of 18 inches, keeping it well trampled while being placed. On top of this manure place the frame and pack manure tightly all around it. Place inside the frame 3 to 4 inches of rich soil and cover with a glass sash. Window sash can often be used for this purpose. The bed should stand for several days, some ventilation being given meanwhile, so that the gases from the manure may escape. When the temperature of the bed has fallen to between 80° and 90° F., the seed may be planted.

FIG. 15.—The other side of the yard seen in figure 14. For several months this garden supplied two elderly people with fresh vegetables.

Another very satisfactory method of constructing a hotbed is to dig a pit to a depth of 18 to 24 inches and in this pack the manure and place the frame over it. This method has the advantage of requiring less manure. In using either method it is a good plan in the fall to cover the ground where the hotbed is to be located with a layer of manure about a foot thick. This covering will keep the soil soft and warm, which will be a great aid when the time comes to construct the hotbed

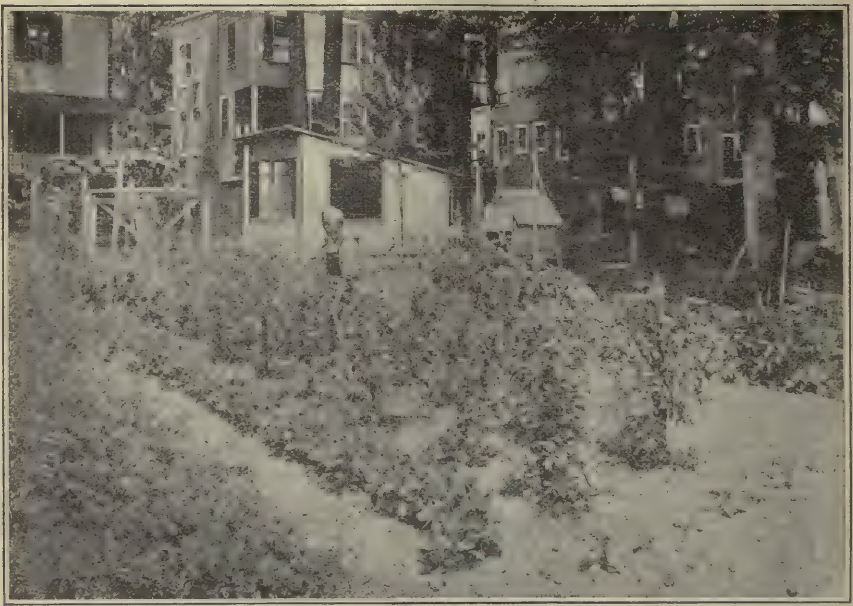

FIG. 16.—A 10-year-old boy in his club garden containing 272 square feet. The result of his labor was $9.05 worth of vegetables.

A hotbed may often be constructed adjoining the house and a pipe from the house heating system used to furnish heat for the bed.

MANAGEMENT OF A HOTBED.

When the temperature of a hotbed has fallen to the required degree, the soil is raked until very fine and all strawy material and refuse removed. The seed is planted in rows 3 inches apart and to a depth of an eighth to a half inch, according to the size of the seed. A thin stick or a lath can be pressed into the soil to give the required depth and to mark the rows. The seed should be covered very lightly with soil.

As the plants grow, they should be watered often enough to keep the soil from drying out, but not enough to keep the soil water-soaked. Water should be applied in a fine spray, and this can be done by using a fine sprinkler on the hose or watering can. The watering should be done early in the day, so that the plants will have time to dry off before night.

Plants should have plenty of fresh air, but should not receive a direct draft or air that is chilly enough to check their growth. The hotbed sash may be raised slightly in the morning after the air becomes warm, but it should be lowered again before it turns cold toward evening. The sash should be opened only on the side opposite from the direction of the wind. On a bright sunny day the sash may be raised several inches, but on a dull day only a very small opening should be made. Always give good ventilation after watering the plants. When the plants become large and the weather is warm, the sash is left off gradually for longer periods, in order to harden the plants.

Such plants as are being grown for setting in the garden should be transplanted into the coldframe as soon as they are about 2 inches high and have three or four leaves. Plants which are to mature crops in the hotbed should be thinned out as soon as they begin to crowd in the row. The soil should be stirred several times and all weeds taken out as soon as they appear. A hand weeder is a useful tool for this purpose.

Radish, lettuce, onions, etc., can be produced very early in the spring in the hotbed. Tomato, cabbage, celery, cauliflower, eggplant, pepper, and kohl-rabi plants should be started in the hotbed in order to have them ready for planting in early spring.

USE OF COLDFRAMES.

A coldframe usually is only a sash-covered frame placed over a portion of good garden soil. No heat is supplied except what comes from the sun. A coldframe is used to protect tender plants during the early spring or late autumn. The management of a coldframe is very similar to that of a hotbed both in regard to watering and in ventilating.

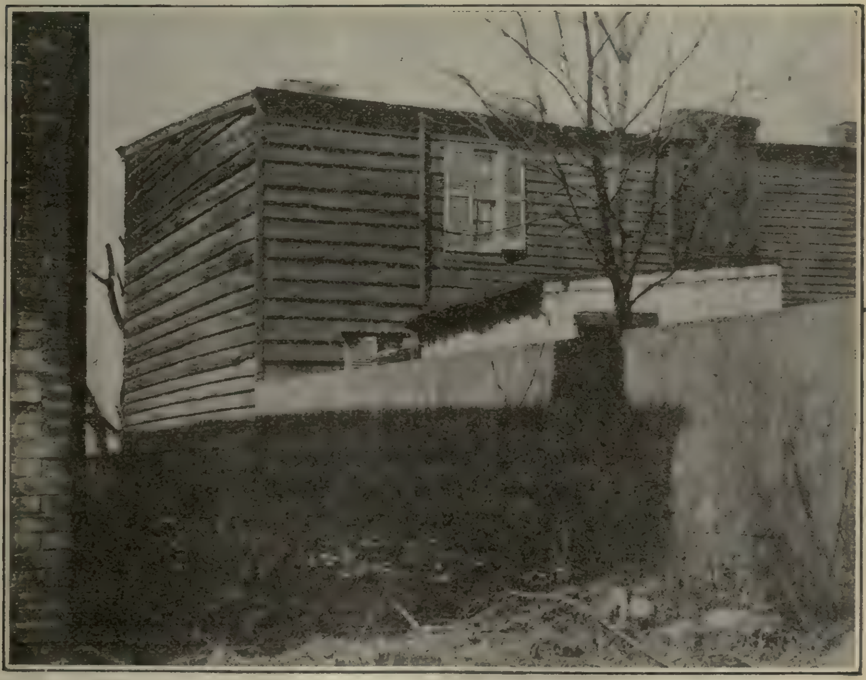

FIG. 17.—An area completely shaded for more than three or four hours of the day. Such areas should never be planted.

FERTILIZING THE GARDEN.

The soil used for growing vegetables should be very rich and well supplied with humus. To produce vegetables of high quality and in a short period of time it is necessary to have large amounts of readily available plant food. Well-rotted stable manure is probably the best fertilizer, because it supplies both the plant food and humus. Wherever it is possible to obtain sufficient manure it should be applied at the rate of 1 to 2 pounds per square foot or a good wheelbarrow load or two to each square rod, depending on the character of the soil. If sufficient manure is not obtainable it can be supplemented by using commercial fertilizer. An application of 3 to 6 pounds per square rod of a high-grade mixture analyzing 8 to 10 per cent phosphoric acid, 2 to 4 per cent nitrogen, and 1 to 3 per cent potash will be satisfactory on many garden soils.

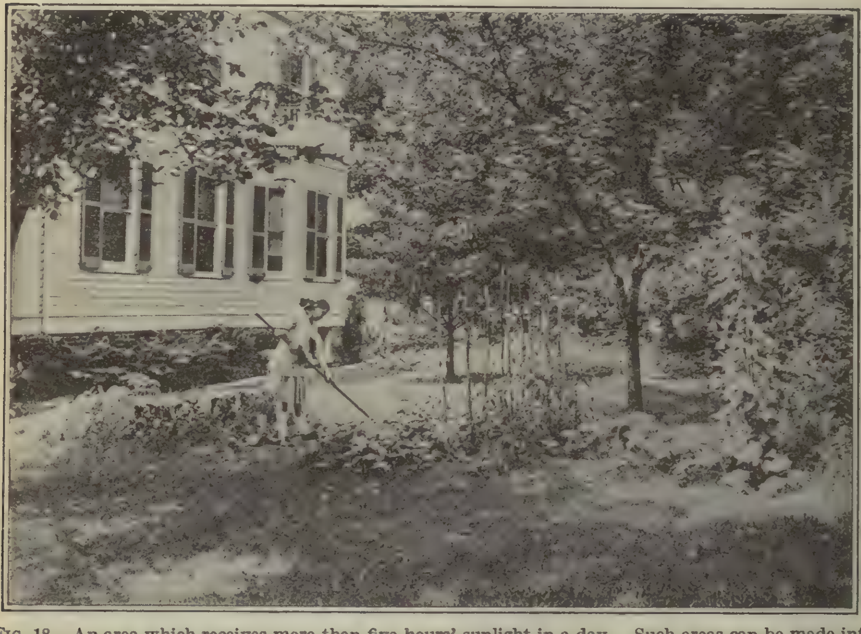

FIG. 18.—An area which receives more than five hours' sunlight in a day. Such areas can be made into successful gardens.

Prepared sheep manure is an excellent fertilizer if it can be obtained at a reasonable price. Nitrate of soda is often used to hasten the growth of some plants. The best method of using nitrate of soda is to dissolve a teaspoonful in a gallon of water and use the solution to water the plants. Do not sprinkle nitrate of soda water over the leaves of the plants, for concentrated solutions are likely to burn the leaves.

When coarse or strawy manure is used it should be applied and plowed under in the fall, but if the stable manure is well rotted it may be applied as a top-dressing and plowed under in the spring. Commercial fertilizer may be applied broadcast over the land after spading and thoroughly mixed with the soil by hoeing and raking, or it may be applied under the row.

A compost heap will furnish plant food that is in a quickly available condition and also soil which can be used in the hotbed, coldframe, and seed flats, and to put under and around plants which require considerable quantities of nitrogen. Such plants as cucumbers, cantaloupes, watermelons, and squashes will be greatly benefited if good compost is used in the hill when the seed is planted.

A compost heap can be easily made. First, select a place near the garden, but screened from view. Put down a layer of sods and over this place alternate layers of manure, sandy soil, and clay soil until the pile is of the desired height. The whole compost pile should be cut down and turned several times during the season, and by the next spring the manure will be thoroughly decayed and mixed with the soil. In the more thickly populated sections of a city compost heaps are not usually allowed, so compost or decayed manure will have to be hauled in from out of the city.

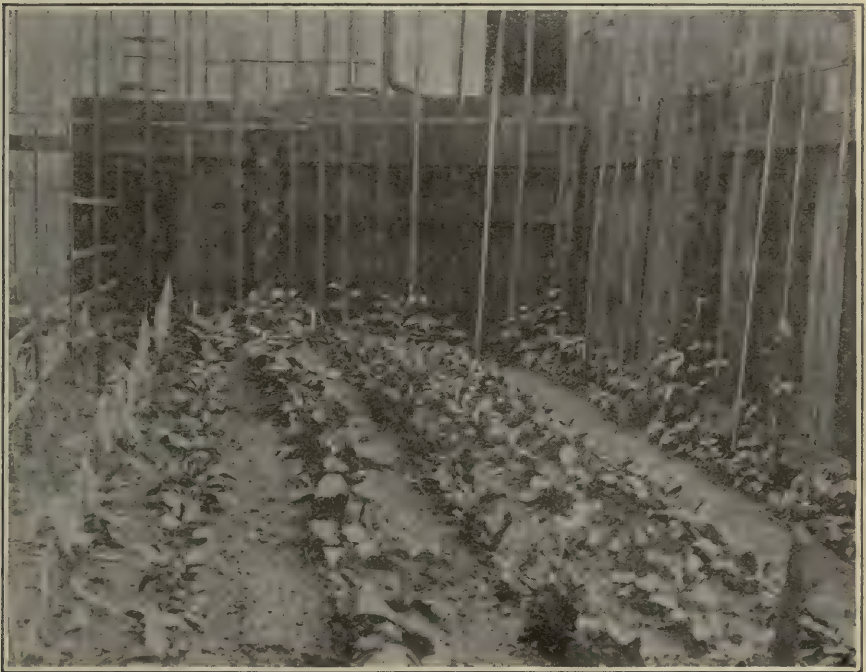

FIG. 19.—A limited space which may be planted to crops such as tomatoes, cabbage, lettuce, snap beans, beets, kale, and radish, with Lima beans on the fence.

It is often possible for the manure from city stables to be collected, taken to dumps located in the suburbs, and there composted. From this source city gardeners may be supplied.

FIG. 20.—A large area which may be planted to crops that require plenty of room. This garden is planted to sweet corn, peas, sweet potatoes, peppers, etc.

The supply of commercial fertilizer should be conserved to the utmost. A satisfactory fertilizer may be had by using 40 pounds of chicken or pigeon manure, both of which are especially rich in nitrogen, 5 to 8 pounds of unleached hardwood ashes, and 5 to 8 pounds of acid phosphate per square rod. The chicken or pigeon manure should be applied separately, as a loss of nitrogen will result if it is mixed with the other ingredients. Many homes burn sufficient wood to produce the necessary quantity of ashes, and comparatively little care is required to collect and save them, while chicken manure is available to most gardeners. Acid phosphate is relatively cheap and comparatively plentiful, but if so desired bone meal may be substituted for it.

LIMING.

Lime added to the soil will help to break up the soil particles and will also correct any acid or sour condition. Lime is not a plant food, but it aids in making the plant food in the soil more available.

Lime may be applied to the soil in the form of burned lime, hydrated lime, or finely ground limestone. Finely ground limestone may be applied either in the fall or in the spring. Burned lime or hydrated lime should not be applied in connection with stable manure because it liberates a great deal of the ammonia in the manure. The manure may be spread on the land and spaded or plowed under. The lime may be scattered over the spaded soil and worked in by hoeing and raking, or by harrowing. If the manure is applied in the fall the lime may be applied in the spring.

Group 4.—Heat-loving plants that can not be safely planted until the ground is warm, such as Lima beans, peppers (plants), eggplant, cucumbers, melons, squash, and sweet potatoes. The table gives the dates in the different zones for all garden crops.

Most gardeners are interested in knowing the earliest dates for planting the various crops, as earliness is much desired. It has been found that the earliest safe dates for planting garden crops can be determined from the average dates of the last killing frost in spring.

FIG. 24.—Cowpeas planted as a rotation crop, to be turned under in order to improve the soil.

The map (fig. 31) divides the continental portion of the United States into zones, with a difference between them of about two weeks in the average date of the last killing frost. The average dates of the last killing frost, while a guide in planting, can not be depended upon every year, but are reasonably safe. There is a difference of several days within the zones themselves, owing to difference in elevation, in latitude, and in proximity to bodies of water. The following table gives the earliest safe dates for planting the various vegetables in the open in the different zones illustrated in figure 31.

EARLIEST PLANTING DATES.

Earliest safe dates for planting vegetables in the open in the zones shown in figure 31.

Crop.	Zone A.	Zone B.	Zone C.	Zone D.	Zone E.	Zone F.	Zone G.
Asparagus	(Not grown)	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to 15	May 1 to June 1.
Artichoke: Globe	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	Apr. 15 to May 15	May 1 to 30	(Not grown)	(Not grown)
Artichoke: Jerusalem	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	May 1 to 30	Do.
Bean: Lima	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	May 1 to 15	May 15 to June 1	May 15 to June 15	
Bean: Snap	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to 30	Apr. 1 to May 1	May 1 to 15	May 15 to June 1	May 15 to June 15.
Beet	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to 15	May 15 to June 1.
Brussels sprouts	do	do	do	do	do	do	Do.
Cabbage	Jan. 1 to Feb. 1	Jan. 15 to Feb. 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to May 15.
Carrot	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to 15	May 1 to June 1.
Cauliflower	do	do	do	do	do	do	Do.
Celery	do	do	do	do	do	do	Do.
Chard	do	do	do	do	do	do	Do.
Collard	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15		
Corn, sweet	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to May 1	Apr. 15 to May 15	May 1 to June 1	May 15 to June 15.
Cucumber	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	Apr. 15 to May 1	May 1 to June 1	May 15 to June 15	June 1 to 15.
Eggplant	do	do	do	Apr. 15 to May 1	do	do	
Garlic	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to 15.
Kale	do	do	do	do	do	do	Do.
Kohl-rabi	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Lettuce: Head	do	do	do	Mar. 15 to Apr. 15	do	do	Do.
Lettuce: Leaf	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to May 15.
Melons	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	Apr. 15 to May 1	May 1 to June 1	June 1 to 15	
Mustard	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Okra, or gumbo	Feb. 15 to Mar 1	Mar. 1 to Mar. 15	Mar. 15 to 30	Apr. 15 to May 1	May 1 to 15	May 15 to June 1	June 1 to 15.
Onion: Seed	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Onion: Sets	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to 15.
Parsley	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Parsnip	do	do	do	do	do	do	Do.
Peas: Smooth	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to June 1.
Peas: Wrinkled	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Peppers	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	Apr. 15 to May 1	May 1 to June 1	June 1 to 15	
Potatoes: Irish	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to June 1.
Potatoes: Sweet	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	Apr. 15 to May 1	May 1 to June 1	June 1 to 15	
Pumpkin	do	do	do	do	do	do	
Radish	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to 15.
Rhubarb	(Not grown)	(Not grown)	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to 15	May 15 to June 1.
Salsify	Feb. 1 to 15	Feb. 15 to Mar. 1	do	do	do	do	Do.
Spinach	do	do	do	do	do	do	Do.
Squash	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	Apr. 15 to May 1	May 1 to June 1	June 1 to 15	
Tomato	do	do	do	do	May 1 to June 1	May 15 to June 15	June 1 to 15.
Turnip	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to 15.

LATEST PLANTING DATES.

Latest safe dates for planting vegetables for the fall garden in the zones[1] shown in figure 32.

Crop.	Zone C.	Zone D.	Zone E.	Zone F.	Zone G.
Bean:					
Bush	Sept. 15	Sept. 1	Aug. 15	Aug. 1	July 15
Pole Lima	...do...	Aug. 1	July 15	July 1	....
Beet	...do...	Sept. 1	Aug. 15	Aug. 1	July 15
Cabbage	Sept. 1	Aug. 15	July 15	July 1	June 15
Carrot	...do...	...do...	...do...	...do...	Do.
Cauliflower	...do...	...do...	...do...	...do...	Do.
Celery	Oct. 1	Sept. 1	Aug. 1	...do...	May 15
Chard, Swiss	Sept. 15	...do...	Aug. 15	Aug. 1	July 15
Corn, sweet	Aug. 15	Aug. 1	July 15	July 1	June 15
Cucumber	...do...	...do...	...do...	...do...	....
Eggplant	July 15	July 1	June 15	June 1	....
Kale	Nov. 1	Oct. 1	Sept. 15	Sept. 1	Aug. 15
Lettuce	...do...	Oct. 15	Oct. 1	Sept. 15	Sept. 1
Melons:					
Muskmelon	June 15	June 1	May 15	May 1	....
Watermelon	July 1	July 1	June 15	....	....
Okra	July 15	...do...	...do...	June 1	....
Onion:					
Seed	June 15	June 1	May 15	May 1	Apr. 15
Sets	July 15	July 1	June 15	June 1	May 15
Parsley	Nov. 1	Oct. 1	Sept. 1	Aug. 1	July 1
Parsnip	....	....	May 15	May 1	Apr. 15
Pea	Nov. 1	Oct. 1	Sept. 1	Aug. 1	July 15
Peppers	July 15	July 1	June 15	June 1	....
Potatoes:					
Irish	Aug. 15	Aug. 1	July 15	July 1	June 15
Sweet	...do...	July 15	June 15	May 1	....
Radish	Oct. 15	Oct. 1	Sept. 15	Sept. 1	Aug. 15
Salsify	June 15	June 1	May 15	May 1	Apr. 15
Spinach	Oct. 15	Oct. 1	Sept. 1	Aug. 15	Aug. 1
Squash:					
Bush	Aug. 15	Aug. 1	July 15	July 1	June 15
Vine	July 15	July 1	June 15	June 1	....
Tomato	Aug. 15	July 15	July 1	June 15	....
Turnip	Oct. 15	Oct. 1	Sept. 1	Aug. 1	July 15

[1] Zones A and B are sections in which many vegetables are planted late in the fall to form the winter garden or early spring garden.

Many crops may be used to make a fall garden, and the latest safe dates for planting in the various zones are shown in the above table, which is to be used in connection with the zones shown in figure 32.

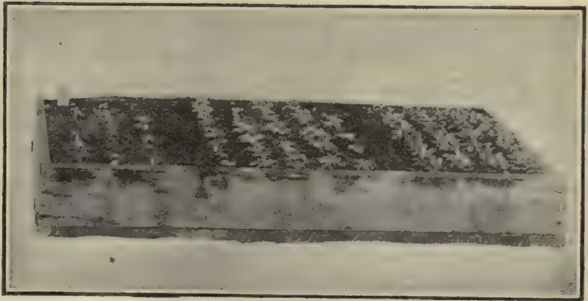

FIG. 25.—A flat, or seed box, useful for starting plants to be planted very early in the season.

SETTING PLANTS.

The soil where plants are to be set should be worked up fine to a depth of several inches, in order to facilitate planting. The plants should be thoroughly watered an hour or so before removing them from the flats or frames, to insure the adherence of the earth to the roots. If the plants have not been transplanted into pots or dirt bands, they should be removed with a ball of earth attached to the roots.

A cloudy day or just before nightfall is the best time to set out plants, though potted plants and plants in dirt bands may be set at any time with good results. The plants should be set a trifle deeper than they were in the seed bed and the soil firmed around each plant from the bottom of the hole to the surface. A trowel or a dibble can be used for making the holes to receive the plants. If water is to be used in setting the plants, it should be poured about the plant when the hole is partially filled with soil. The moist earth is then covered with dry soil, which prevents the rapid evaporation of the moisture.

Cabbage and lettuce plants may be set in the open as soon as the ground can be worked in the spring, but many plants, such as the tomato, pepper, and eggplant, should not be set out until the weather has become warm, as indicated in the table and the zone maps. Some time may be gained by setting the tender plants before danger of frost is over and then protecting them by covering with newspapers, tin cans, berry boxes, or plant covers. These covers may be put over the plants at night when frosts are likely to occur, and if partially removed in the morning they will shade the newly set plants.

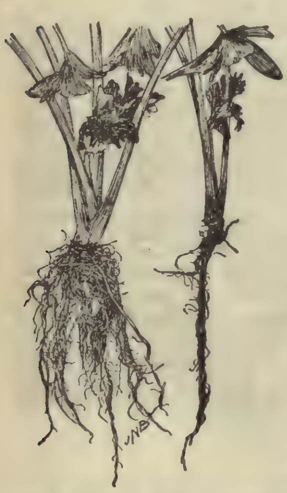

FIG. 23.—Celery plants, showing the effect of transplanting on the root system.

CULTIVATION.

Thorough preparation of the seed bed and good seed properly planted are very essential for successful gardens, but unless the plants are properly cultivated during the season the garden will prove a failure. Cultivation is not entirely for the purpose of killing the weeds, but has as its main object the conserving of soil moisture. Frequent shallow cultivation forms a soil mulch which prevents the loss of moisture, and frequent stirring prevents the growth of weeds. The soil close to the plants should be kept fine and free from weeds, the same as the spaces between the rows. If the cultivation is begun as soon as the plants show and is kept up at regular intervals throughout the season, the work does not become burdensome. If cultivation is given only occasionally, the plants may suffer (fig. 33), and the work is arduous and unsatisfactory. Cultivate the land after every rain, so as to break up the crust that has formed, and give other cultivation as needed to form a soil mulch and keep down weeds.

If the garden has been laid out with long rows and a medium-wide space between the rows, most of the cultivation may be done with a hand cultivator. With such a cultivator the work may be very quickly and efficiently done. In many instances very efficient work can be done with a hoe, but the larger share of the work of cultivating can be performed much more quickly with a hand cultivator.

IRRIGATION.

A good supply of water in the soil is necessary throughout the growing season, to enable the plants to grow vigorously. Many times during long periods of hot, dry weather the supply of moisture in the soil becomes very low, and the plants are so checked in growth that they fail to produce any crop, or at best produce a very poor one. Where a supply of water is available it is often possible to establish an irrigation system which will insure an abundance of water for the plants at a relatively small expense.

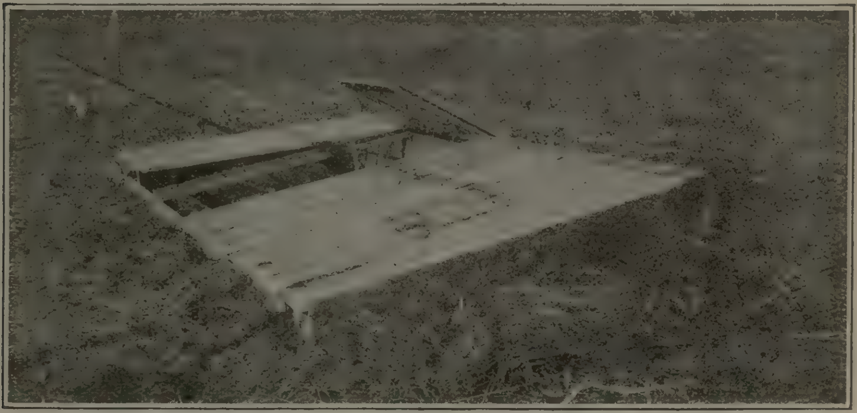

FIG. 27.—A suitable frame for carrying sash for a coldframe or hotbed for a city garden.

Several systems of irrigation are adapted to the garden. An overhead system is probably best. By one such system the water is applied by means of elevated pipes placed at regular intervals over the garden. Nozzles are set in these pipes every 2 feet, and the pressure on the water forces out a fine stream or mist. Water may also be applied to the garden crops by means of a hose by running the water in furrows between the rows or by running the water in tile placed under the soil. The chief factor that must be considered in any system of irrigation is a sufficient supply of water.

CONTROL OF INSECTS AND DISEASES.

Preventive measures are best in the control of insects and diseases. (Fig. 34.) All old vines, cabbage stalks, and the remains of the various crops should be gathered and burned in the autumn. This destroys many insects and to a large measure will prevent the spread of diseases. Following each crop with something not related to it will aid in keeping down insects and diseases. The hand picking of such insects as the Colorado potato beetle is to be recommended. The use of air-slaked lime or dust as a deterrent for insects is effective and inexpensive. The control of garden insects and diseases is fully covered in Farmers' Bulletin 856, "Control of Diseases and Insect Enemies of the Home Vegetable Garden," to which the reader is referred for further information.

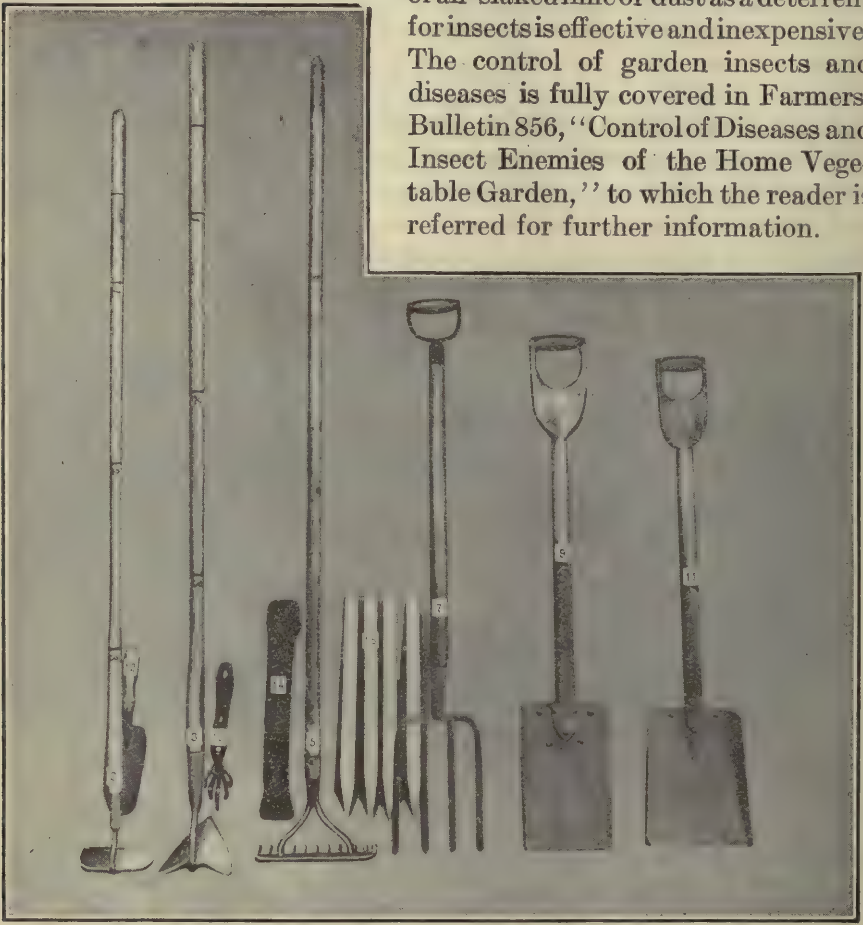

FIG. 28.—A set of garden tools, including the essential implements and a few others. (2) Hoe, (3) heart-shaped furrow hoe, (5) steel-tooth rake, (7) fork, (9) spade, (11) shovel, (12) trowel, (13) scratch weeder, (14) line, (15) stakes. Note that the handles of some of the longer implements are marked off in feet and half feet for convenience in measuring.

SAVING SURPLUS VEGETABLES.

It is just as important to utilize all surplus vegetables as it is to raise them. Those vegetables that are not needed when freshly harvested may be stored, canned, or dried for use during the months when few vegetables are available in the garden. Vegetables may be easily stored with the facilities in or near the ordinary home. Small pits (fig. 35) may be made in the ground, or a portion of the house cellar (fig. 36) may be partitioned off to serve as a storage cellar.

For details of the storage of vegetables, read Farmers' Bulletin 879, entitled "Home Storage of Vegetables."

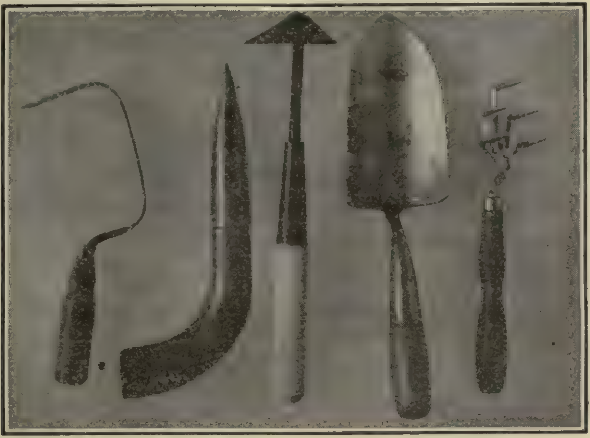

FIG. 29.—Some small tools useful in the home garden. From left to right they are: Hand weeder, dibble, onion hoe, trowel, and scratch or claw weeder.

Detailed directions for canning vegetables are to be found in Farmers' Bulletins 839 [1] and 853 [2] and for drying in Farmers' Bulletin 841.[3]

DIRECTIONS FOR GROWING VEGETABLE CROPS.

ASPARAGUS.

Asparagus should be grown in every home garden where it will thrive, because it is one of the earliest vegetables and is a valuable addition to the spring diet. The soil for asparagus should be made quite rich by the application of partly rotted manure before the plants are set. As soon as danger from hard frosts is over, the seeds of asparagus may be sown in the rows where the plants are to remain. Soaking the seed in hot water for an hour or two before planting will hasten germination.

The seedlings should be thinned to stand 15 inches apart in the row. Quicker results can be secured,

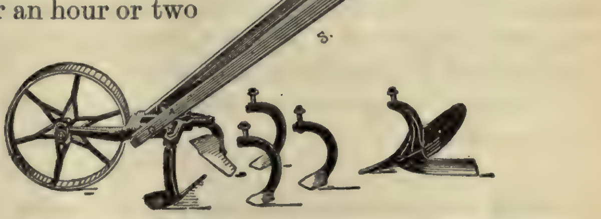

FIG. 30.—A wheel hoe, a valuable addition to any vegetable garden.

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[1] Entitled "Home Canning by the One-Period Cold-Pack Method Taught to Canning Club Members in the Northern and Western States."

[2] Entitled "Home Canning of Fruits and Vegetables as Taught to Canning Club Members in the Southern States."

[3] Entitled "Drying Fruits and Vegetables in the Home, with Recipes for Cooking."

however, by buying roots from some seedsman or dealer. The roots may be planted in the autumn or early spring. Before setting the plants, the soil should be loosened deeply by spading or by the use of a subsoil plow. The roots may be set in a solid bed 1 foot apart each way. Cover the roots to the depth of 4 or 5 inches. The bed should receive a dressing of manure or fertilizer each year, preferably in the autumn.

No shoots should be removed the first year the plants are set in the permanent bed, and the cutting season should be short the second year. After the bed is well established, with proper care and fertilizing it should last indefinitely. During the cutting season, all of the shoots, even those too small for use, should be removed.

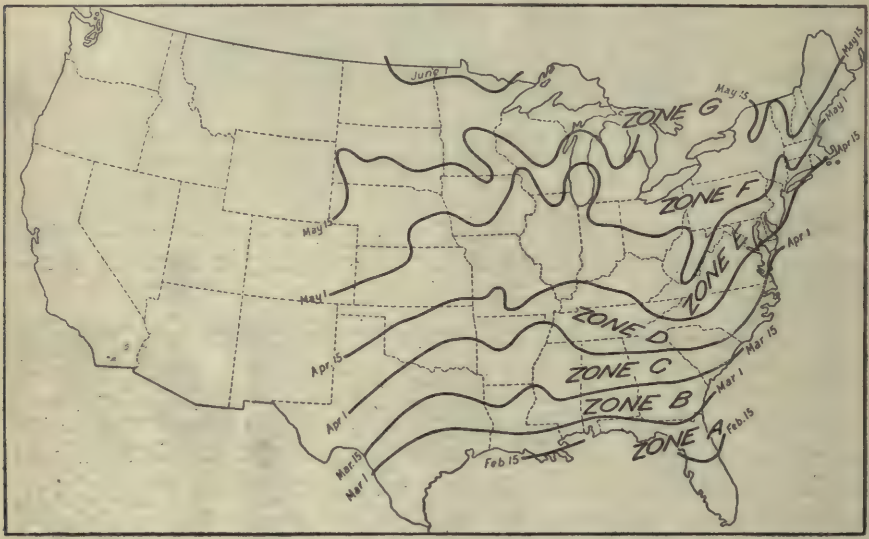

FIG. 31.—Outline map of the United States, showing zones based on the average date of the last killing frost in spring. The time of planting for the various vegetables is determined for every section by the dates given on this map.

After this, the tops should be allowed to grow until late in the season, when they should be removed and burned and the soil between the rows cultivated. Apply a dressing of manure after cultivation and allow it to remain on the bed.

Varieties recommended: Palmetto, Reading Giant, and Giant Argenteuil.

BEANS.

Beans will not withstand much cold, so they should not be planted until danger of frost is past and the ground begins to warm up. The first planting should be made as soon as the ground is reasonably warm, and other plantings may be made at intervals of ten days or two weeks until hot weather sets in. Beans for the fall garden should be planted in late summer, and successive plantings may be made at the intervals suggested until about eight weeks before time for the first frost in the autumn.

Bush beans should be planted to stand 2 to 3 inches apart in rows 20 to 24 inches apart. Among the best varieties of bush beans are the Stringless Green Pod, Refugee, Hodson's Kidney Wax, Currie's Rustproof Wax, and Wardwell's Kidney Wax.

Lima beans, both pole and bush, should be grown in the garden (fig. 37). These should be planted after all danger of frost is over and the soil is warm. Plant the pole beans 8 to 10 seeds in a hill and thin to 3 or 4 after the plants become established. The hills should be 4 or 5 feet apart. For bush Lima beans, plant 5 or 6 inches apart in rows 30 to 36 inches apart.

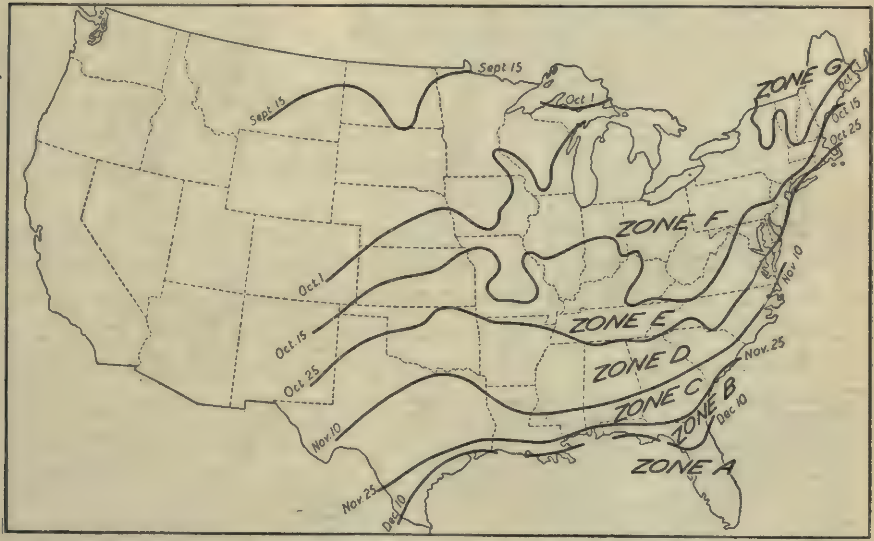

FIG. 32.—Outline map of the United States, showing zones based on the average date of the first killing frost in the autumn. The latest safe dates for planting vegetables in the autumn are determined by the dates given on this map.

When planting beans of any kind the seed should not be covered over 2 inches, and on heavy soils they should not be covered more than 1¼ to 1½ inches.

Varieties recommended: Seibert's Pole Lima, Carpinteria Lima, and King of the Limas are good varieties of pole Lima beans, and Fordhook Bush Lima, Dreer's Bush Lima, and Henderson's Bush Lima are good varieties of the bush type.

BEETS.

Beets (fig. 38) can be planted as soon as the ground can be worked up mellow in the spring, even before the ground has become warm. Sow the seeds in drills 14 to 18 inches apart, covering to the depth of about 1 inch. As soon as the plants are well up, thin them to stand 4 to 5 inches apart. Make two or three plantings, so as to have a continuous supply of young, tender beets throughout the season. In many sections of the South beets may be left in the ground through the winter, to be pulled when wanted.

Varieties recommended: Crosby's Egyptian, Bassano, Early Eclipse, and Early Blood Turnip.

CABBAGE.

In Florida and the Gulf coast region of the other Southern States cabbage seed may be sown in the open any time from September to January. Along the Atlantic coast, from Charleston, S. C., to Florida, seed may be sown in the open in October. In all other sections of the South hotbeds or coldframes should be used for starting the plants.

For spring and early-summer cabbage the following varieties are recommended: Jersey Wakefield, Charleston Wakefield, Allhead Early, and Succession. The Copenhagen Market, a new variety, has given excellent results in many localities and is well worthy of a trial. The Flat Dutch and Danish Ball Head are desirable late varieties for the Northern States.

In most sections of the South it is not advisable to grow cabbage during midsummer, but a fall crop should be grown. The same varieties may be grown in the autumn as in the spring, but it is usually desirable to plant larger varieties, such as Flat Dutch or Danish Ball Head. Seed for the fall crop should be planted in a cool loca-

FIG. 33.—A poorly kept garden, involving a waste of time, energy, and seed.

tion in late summer and the plants set out as soon as they reach the proper size and the soil contains sufficient moisture to start growth. Cabbage plants should be set 14 to 18 inches apart in rows 30 to 36 inches apart. The earlier varieties, which grow small heads, are usually set closer than the later ones.

CARROT.

The soil and cultural requirements of carrots are practically the same as for beets. Carrot seed, however, should not be planted so deep as beet seed, and the plants can be allowed to grow closer together in the row (fig. 39). Carrots may be dug in the autumn and stored in banks or cellars, or they may be left in the ground to be harvested as needed.

Varieties recommended: Half-Long Danvers, Early Scarlet Horn, and Chantenay.

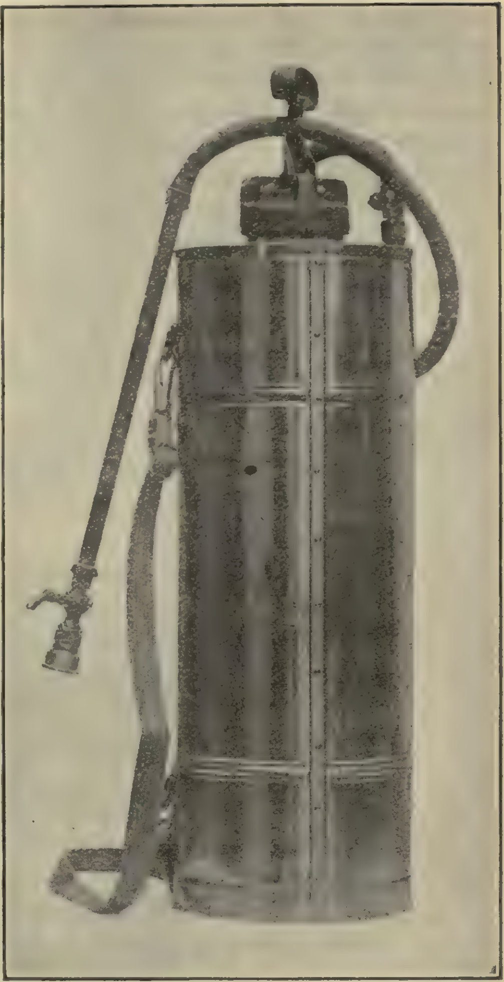

FIG. 34.—A type of compressed-air sprayer which is very useful in a home garden.

CAULIFLOWER.

Cauliflower thrives best on a rich, moist soil. The culture of this crop is about the same as for cabbage, but it will not withstand as much frost. In order to secure bleached heads it is necessary to protect them from the sun (fig. 40). The usual practice is to tie the leaves together over the heads.

Varieties recommended: Early Snowball and Dwarf Erfurt are the varieties of cauliflower most commonly grown.

CELERY.

In the lower South celery is grown as a fall crop, as it will not mature during hot weather. The seed is sown in a cool, shady place in late summer and the plants set out in the autumn as soon as the soil becomes moist. The seed should be sown in rows and covered lightly (not more than one-eighth of an inch) or sown broadcast and covered with burlap, straw, or some other material, to prevent the loss of moisture while the seed is germinating. It will be necessary to water the seed bed often during dry weather.

In the North or upper South celery may be grown in the spring or in the autumn. As a spring crop, the seed should be started in a hotbed during the winter so that the plants may mature before midsummer. Celery does not bleach well in hot weather, but rots when banked or boarded for bleaching.

Set the celery plants 6 inches apart in rows 3 feet apart for horse cultivation, or 18 to 24 inches apart when hand cultivation is to be employed.

Celery requires a deep, rich, moist soil and frequent shallow cultivation. When grown as a fall crop celery may be planted after some other crop, such as peas, beans, cabbage, lettuce, or radishes. When the celery plants are nearly grown a little soil should be drawn around the base to hold the plants in place. About two weeks before they are wanted for the table the bleaching should begin. Soil, boards, or paper may be used for bleaching, but soil should be employed only when the weather is cool. When soil is to be used for bleaching, the rows should be 4 feet apart. Some quick-maturing crop could be grown between the rows of celery to make use of the space up to the time for bleaching.

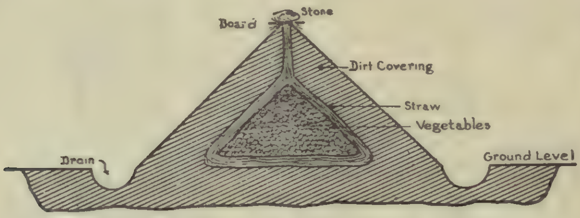

FIG. 35.—A method for the storage of root crops. Cross section of a storage pit containing Irish potatoes. During severely cold weather the dirt covering may be supplemented by manure, straw, etc.

Varieties recommended: Golden Self-Blanching, Columbia, and White Plume.

COLLARD.

A group of nonheading cabbages differing slightly from kale, but withstanding summer heat better than either kale or cabbage, is extensively grown throughout the South under the name of Georgia collards. Collards do not make a true head, but form a rosette of leaves, which are very tender. The culture and uses of this plant are the same as those of cabbage and kale.

CHARD, SWISS.

Swiss chard is a beet plant that has been developed for the foliage instead of for the root (see fig. 38). The leaves continue to develop throughout the season and are picked off when small. Two or three of the central shoots are always left to carry on the growth. Chard is planted like beets in rows 12 to 14 inches apart and gradually thinned out so the plants stand 12 inches apart in the row. The seed is sown at the same time as beets and the leaves are ready for use in about five weeks. The fleshy leafstalk is very often used the same as asparagus.

Swiss chard is especially useful in the small garden because the leaves can be used for greens in place of spinach and a sufficient number of plants occupy only a small fraction of the space needed to raise the required supply of spinach.

Giant Lucullus is the variety commonly grown.

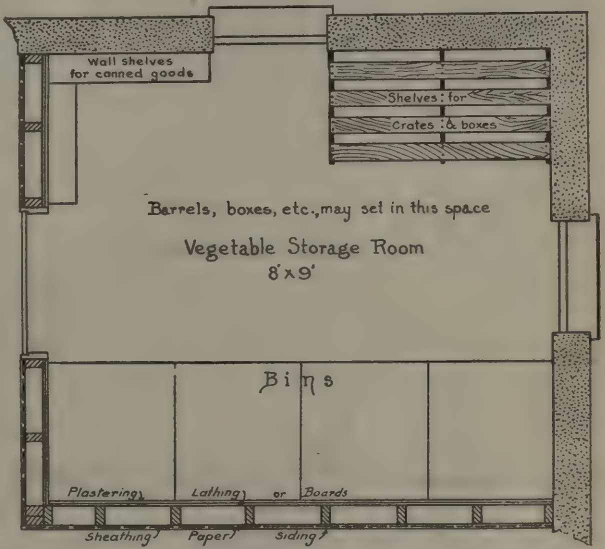
Wall shelves for canned goods
Shelves for Crates & boxes
Barrels, boxes, etc., may set in this space
Vegetable Storage Room 8'x9'
Bins
Plastering, Lathing or Boards
Sheathing
Paper
Siding

FIG. 36.—A plan showing how a storage room may be made in the cellar of a dwelling. The arrangement of the shelving and bins may be changed to suit conditions. While the construction of the wall may be varied, it must be tight.

CORN, SWEET.

Sweet corn should be planted on rich land and cultivated the same as field corn (fig. 41). Plant the seed as soon as the soil is warm in the spring, and make successive plantings every two or three weeks until late summer. The same results can be obtained to some extent by planting early, medium, and late varieties. Plant the seeds about 2 inches deep in drills 3 feet apart, and thin to a single stalk every 10 to 14 inches.

The flavor of sweet corn depends upon the stage of maturity and the method of handling the product from the plant to the table. Sweet corn loses its flavor very rapidly after being removed from the stalk. It should, therefore, be picked only a few hours, and preferably a few minutes, in advance of the time when it is to be placed in the pot.

Varieties recommended: For early corn Golden Bantam and Adams Early are suggested, and for medium and late varieties Black Mexican, Country Gentleman, and Stowell's Evergreen. The last-named variety has the largest ears and is the most productive.

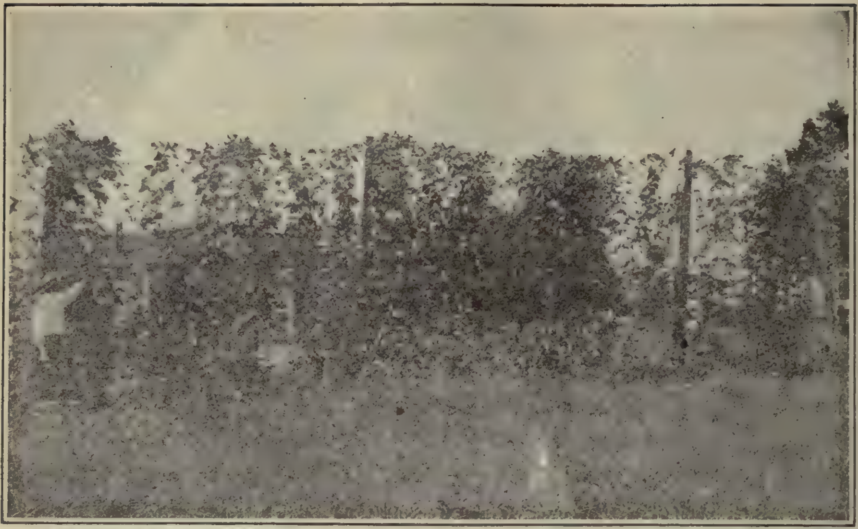

FIG. 37.—A tennis backstop forming a good support for Lima beans. The yield from these vines was 25 quarts of shelled beans.

CUCUMBERS.

The soil for cucumbers should be rich, and it is a good plan to apply well-rotted manure under the rows or hills. If planted in rows, open the furrow and scatter the manure along the furrow, turning fresh soil over the manure before planting the seeds. If the seeds are planted in hills, confine the application of manure to the area occupied by the hills.

As cucumbers are easily injured by cold, it is not advisable to plant until all danger of frost is over and the ground has begun to warm up. For very early cucumbers the seeds should be planted in a hotbed in old strawberry boxes or plant bands or directly in the soil of the bed. By starting the plants in hotbeds the cucumbers will be ready for the table two or three weeks earlier than if started in the open. For the main crop, drill the seed in rows 5 feet apart, and after the plants reach a height of 3 or 4 inches thin them to stand 12 to 18 inches apart in the row, or plant the seeds in hills 4 feet apart each way and thin to two or three plants to the hill.

Cucumbers should be given frequent shallow cultivation until the vines fill most of the space between the rows; after this very little attention will be needed, except to pull out any weeds by hand. Do not allow any fruit to ripen on the vines until the end of the picking season, as new fruits will not form while older ones are ripening.

Young cucumber plants are often destroyed by the cucumber beetle. It is possible to protect the plants by covering them with small wooden frames over which mosquito netting has been stretched.

Air-slaked lime sprinkled over the small plants is an added protection against the cucumber beetle.

Varieties recommended: White Spine, Davis Perfect, and Emerald.

EGGPLANT.

The plants for this crop should be started in a hotbed or in a box in the house about two months before time for planting in the garden. The plants should not be set in the field until after all danger of frost has passed and the ground has become quite warm. Set the plants 18 to 24 inches apart in rows 3 feet apart, and give clean, shallow cultivation to keep the plants growing rapidly. A dozen good,

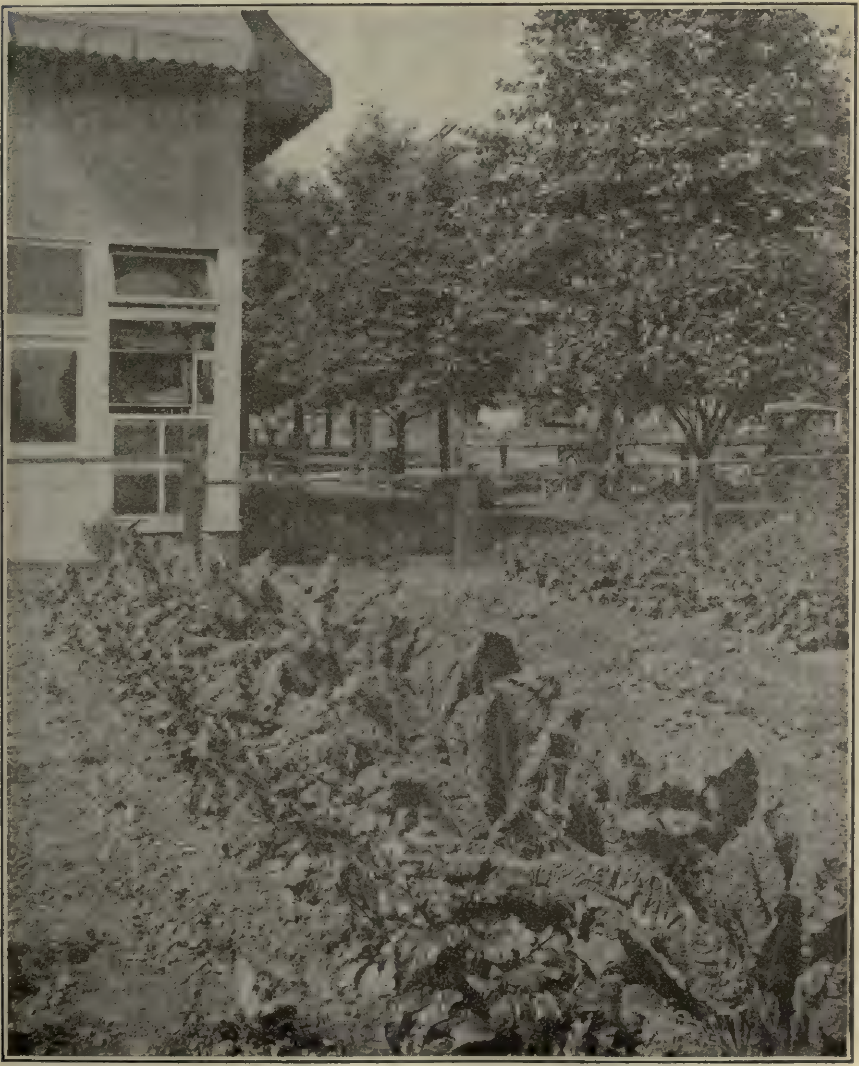

FIG. 38.—Beets and Swiss chard, excellent crops in any home garden.

healthy plants will supply enough fruit for the average-sized family throughout the season.

Varieties recommended: New York Improved Purple and Black Beauty.

GARLIC.

Garlic is propagated by separating the bulbs into the small bulblets, or cloves, and planting these separately in rows 12 to 14 inches apart and from 3 to 4 inches apart in the row, either in the autumn or spring. In other respects the cultivation is the same as for onions. The mature bulbs are pulled and left on the ground until the tops are dry, when they are gathered, braided together, and hung in a shed to cure. Garlic is used for flavoring purposes.

KALE.

Kale is a very hardy crop and can be grown in the open during the winter in practically all sections of the South. In the more northern sections it is grown either as a spring or fall crop. Sow the seed in drills 18 inches apart, and thin the plants to stand 4 or 6 inches apart in the row. Seed for the spring crop may be sown as soon as the soil can be conveniently worked. Seed for the fall or winter crop may be sown in early autumn.

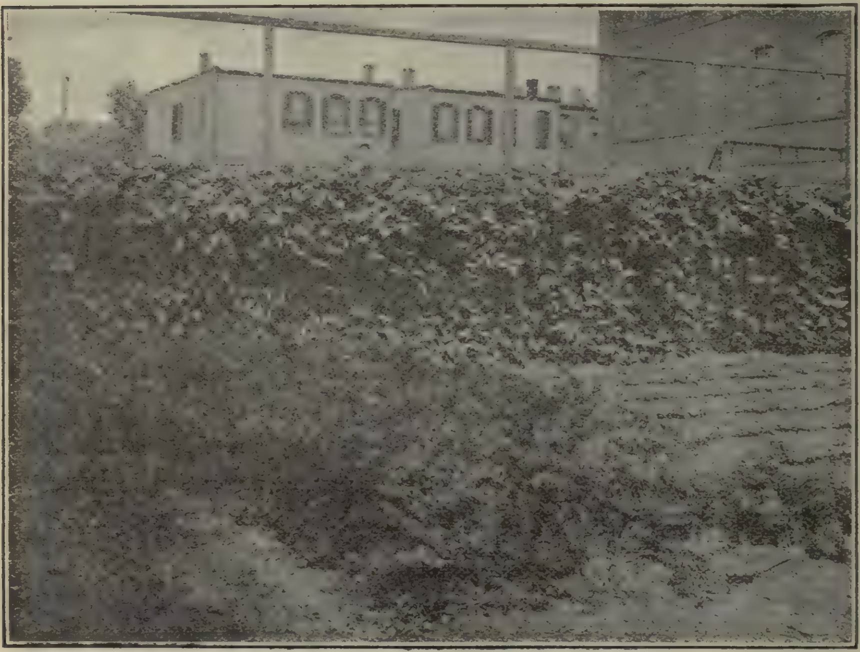

FIG. 39.—A patch of excellent carrots in a city garden.

Varieties recommended: Dwarf Curled, Tall Scotch, and Siberian.

KOHL-RABI.

Kohl-rabi belongs to the same class as cabbage and cauliflower, but does not resemble either. The edible portion is the swollen stem, which resembles a turnip, but which is formed above ground. Kohlrabi should be grown both in the spring and in the autumn. Sow the seed in drills and thin the plants to 6 inches apart in the row. The rows should be 18 inches apart. The fleshy stems should be used while fresh and tender, as they become tough and stringy within a short time.

FIG. 40.—A row of cauliflower in a vacant lot garden. The leaves are tied at the top to keep the heads white.

Variety recommended: White Vienna.

LETTUCE.

Lettuce thrives best during cool weatner, so it should be planted in the spring and autumn. In order that the leaves or head may be crisp, the crop should be forced and successive plantings made ten days or two weeks apart. In the lower South lettuce can be grown in the open during the winter, but in the North hotbeds or coldframes must be used.

When grown in the garden, the seeds should be sown in rows 14 to 16 inches apart and the plants thinned to the desired distance. The heading type should be thinned to stand 8 inches apart in the row, but with the loose-leaf type the plants may be grown close together and thinned as needed for the table. For a very early crop, start the plants in the hotbed or coldframe and transplant the young plants to the garden as soon as hard freezes are over. Give the plants frequent shallow cultivations.

Varieties recommended: Grand Rapids and Black-Seeded Simpson for loose-leaf lettuce, and Big Boston, Hanson, and California Cream Butter for head lettuce.

MELONS.

Muskmelon.—The culture of the muskmelon is the same as for the cucumber, except that the plants are usually given more space. Plant 8 to 10 seeds in a hill, spacing the hills 6 feet apart each way. After the plants become established, thin out all but four of the best ones. Another method is to sow in drills 6 feet apart and thin to single plants 18 to 24 inches apart.

FIG. 41.—Corn grown in a lot utilized as a home garden.

Varieties recommended: Rocky Ford, Netted Gem, Emerald Gem, Paul Rose, and Osage.

Watermelon.—The cultivation of the watermelon is the same as for the cucumber and muskmelon, except that the plants require more space. Plant watermelon seeds in rows 8 to 10 feet apart and thin to single plants 3 feet apart, or plant in hills 8 to 10 feet apart each way.

Varieties recommended: Kleckley Sweets, Florida Favorite, Georgia Rattlesnake, and Tom Watson.

MUSTARD.

Mustard is used largely for greens and can be grown in early spring and late autumn. The seeds for the spring crop should be sown as soon as the soil can be put into condition. For the fall crop, sow the seeds in the late summer or early autumn in drills about 1 foot apart. As the plants require but a short time in which to reach edible maturity, frequent sowings should be made.

Varieties recommended: Giant Ostrich Plume and Large-Leaved Curled.

OKRA, OR GUMBO.

Okra is a plant that is especially desirable in southern gardens. Sow seeds in the open after danger of frost is over and the soil becomes quite warm. The rows should be 3 to 4 feet apart for dwarf varieties and 4 to 5 feet for the tall kinds. Sow the seed a few inches apart in the row and thin the plants to 18 inches to 2 feet apart. Give frequent shallow cultivations until the plants are nearly grown.

The pods are the part of the plant used for food and should be gathered while still crisp and tender. If the pods are removed so as to allow none to ripen, the plants will continue to bear until killed by frost.

Varieties recommended: White Velvet, Dwarf Green Prolific, Perkins Mammoth, Long Podded, and Lady Finger.

ONIONS.

For very early bunch onions it is the common practice to plant sets in drills 12 to 14 inches apart and 2 to 3 inches apart in the row. In the South the sets may be put out in the autumn or as early in the spring as the land can be prepared. In the North the sets are put out as soon as the ground can be worked in the spring.

For dry onions, sow the seed thickly in drills about 12 to 14 inches apart in the spring as soon as danger from hard frosts is over. For early bulbs the seed may be planted in a hotbed or coldframe and the young plants transplanted to the open when conditions are favorable. Plants 4 or 5 inches high are of good size for transplanting.

Onions require frequent shallow cultivations and it may be necessary to resort to hand weeding. When the tops begin to die and the bulbs are full grown, the onions should be pulled and left in the field for a few days to dry. Then the tops should be clipped off and the bulbs placed in crates or bags and stored in a well-ventilated place to cure.

Early green onions may also be produced from the Multiplier or Potato varieties planted in the autumn. The large bulbs of these onions contain a number of "hearts", or buds, and if planted will produce a number of small onions. The small onions have but one heart and will produce large bulbs. A few large bulbs should be planted each year to produce sets for fall planting.

The Top, or Tree, onion produces a number of bulblets on top of the stem. These small bulbs can be planted in the autumn and will produce onions the following spring.

Varieties recommended: Southport White Globe, Southport Red Globe, Southport Yellow Globe, Danvers, Red Wethersfield, Australian Brown, and Prize Taker. In some sections of the South the Creole is grown and the Louisiana, or Red Creole, is a popular variety. The Bermuda is a good type of mild-flavored onion and is a desirable type to grow in the South. The important varieties of the Bermuda are Crystal Wax, White Bermuda, and Red Bermuda.

OYSTER PLANT. See SALSIFY.

PARSLEY.

Parsley is used mainly for garnishing meats, but can be used for flavoring soups and other foods. Sow parsley seed thickly in a drill or sow broadcast and cover lightly, either in the autumn or early spring. A space a yard square will be sufficient for parsley.

Varieties recommended: Plain Leaved and Double Curled.

PARSNIP.

Sow parsnip seed in the spring as soon as danger of hard frosts is over, in drills 14 to 16 inches apart. Thin the plants to stand 3 inches apart in the rows. The cultivation of parsnips should be about the same as for beets and carrots. A crop may be planted in midsummer for winter use, and the roots may be left in the ground through the winter or until needed, as freezing is believed to improve the flavor of parsnips. If it is desired to plow the garden before the parsnips are disposed of, they may be dug and stored in a cool place or buried in banks or pits.

Varieties recommended: Hollow Crown and Student.

PEAS.

Garden peas, sometimes called English peas, are not injured by light frosts, so they should be planted as soon as the soil can be put in order in the spring. The first plantings should be of small-growing, quick-maturing varieties, such as Alaska, First and Best, and Gradus, which do not require supports. These varieties should be followed by the large wrinkled type of peas, such as Champion of England, Telephone, and Prize Taker. The large-growing varieties should be supported on brush, on strings attached to stakes driven in the ground, or on wire netting. In order to have a continuous supply of peas, plantings should be made every 10 days or two weeks until warm weather. Peas should be planted in late summer and autumn for the fall garden, for which the early varieties are more desirable than the late ones.

Peas should be planted about 2 to 3 inches deep in rows 3 to 4 feet apart. Some gardeners, however, follow the practice of planting in double rows 6 inches apart, with the ordinary space of 3 to 4 feet between these pairs of rows. This is a good practice with varieties requiring support, as the supports can be placed in the narrow space between the rows.

Varieties recommended: Alaska, First and Best, Gradus, Telephone, Champion of England, and Prize Taker.

PEPPERS.

Seeds of peppers should be sown in a hotbed or in a box in the house about eight weeks before time for setting the plants in the garden. The plants are tender and should not be transplanted until the ground is warm and all danger of frost is past. Set the plants 15 to 18 inches apart in rows 2½ to 3 feet apart. The cultivation and treatment of peppers should be the same as that of tomatoes and eggplants. There is a large number of varieties of peppers, including the sweet kinds and the hot peppers.

Varieties recommended: Ruby King, Chinese Giant, Sweet Spanish, and Bell or Bull Nose, of the sweet peppers; Long Red Cayenne, Tabasco, and Red Cluster, of the hot types.

POTATOES.

Irish or white potatoes.—A small area of early potatoes should be grown in the garden, but the main crop should be grown elsewhere. Early potatoes should be planted as soon as the ground can be prepared to good advantage. In Florida, potatoes are usually planted in December, while in other sections of the lower South they are planted in January. In the upper South early potatoes are usually planted in February, but in the Northern States they are not planted until March or April.

Potatoes are planted 12 to 14 inches apart in rows 2½ to 3 feet apart and covered to the depth of about 4 inches. Potatoes planted during hot weather sohuld be covered 6 inches deep unless they have been sprouted before planting. The furrows are opened and the potatoes dropped, one piece in a place, in the bottom of the furrow. As it requires two or three weeks for potatoes to come up, it is important that they be cultivated as soon as the row can be followed. If a crust forms before the potatoes come up, a rake should be run over the ground to loosen the surface of the soil. Hand cultivators should be used for the main cultivation, but at the last cultivation the soil may be worked up around the plants to hold them erect and to protect the tubers from the sun.

After digging the early potatoes they should be kept in a cool, dry place during the hot weather of summer. In the South it is better to grow a fall crop rather than to try to keep the spring crop through the summer and winter. Fall-grown potatoes can be kept in a dry cellar, in a pit, or in any building where the temperature can be controlled. Irish potatoes keep best in a cool temperature, but should not be allowed to reach the freezing point. It is best not to allow the temperature to fall below 36° F.

Varieties recommended: Irish Cobbler, Bliss Red Triumph, and Early Rose are good, early potatoes. Where only one variety is to be grown, the Irish Cobbler is recommended. In the South the same varieties may be grown for the fall crop, or the Green Mountain, which is a late variety, may be used. In the North the Green Mountain and Rural New Yorker are commonly used for late varieties.

RADISH.

The radish is quite hardy and may be grown in the open all winter in the South and in coldframes in the North. Sow the seed in the open ground as soon as danger of hard frosts is over, or in coldframes whenever space is available. In the open, sow the seed in drills 12 to 15 inches apart and thin the plants to 1 inch apart. Successive plantings should be made every 10 days or two weeks until hot weather comes and again in the autumn when the weather begins to get cool.

Varieties recommended: There are three types of radishes—turnip shaped, olive shaped, and long. Of the turnip shaped, the best varieties are the Scarlet Globe and Scarlet Turnip. The best of the olive-shaped sorts are the French Breakfast and Early Scarlet. The Long Scarlet Chartier, Long White Spanish, and Icicle are the best varieties of the long type.

RHUBARB.

Rhubarb can be grown in the North and the upper South, but can not be grown satisfactorily in the lower South. For home use it is best to buy roots from a dealer rather than to grow plants from seed. Ten to twelve good hills are sufficient for the average family.

Set the roots 3 to 4 feet apart along the garden fence and manure heavily. The treatment suggested for asparagus is satisfactory for rhubarb. Do not allow the plants to go to seed.

SALSIFY, OR VEGETABLE OYSTER.

Sow seeds of salsify at the same time and in the same manner as those of parsnips and carrots. An ounce of seed will plant a 100-foot row and will be sufficient for an average family. After the plants are up, thin them to about 2 inches apart in the row. Salsify may be dug and stored the same as parsnips and carrots or left in the soil until needed. It is a biennial, and if the roots are not dug they will produce seed the second season. Salsify deserves more general cultivation, as it is one of the most desirable root crops.

The Sandwich Island is the variety commonly grown.

SPINACH.

Spinach is one of the best crops grown for greens and should be found in every large home garden. It can be grown in the open throughout the autumn and winter in all sections along the coast from Norfolk, Va., south and in the lower tier of Southern States. In the lower portions of the northern sections it requires protection during the coldest weather. Two or three inches of hay, straw, or leaves will be a satisfactory protection. The seed planted in the autumn will furnish greens through the winter and early spring in the warmer sections. In the Northern States the crop is usually grown in the spring.

Sow the seeds of spinach in drills 12 to 15 inches apart at the rate of 1 ounce to 100 feet of row. Three or four ounces of seed will produce enough greens for the average family. In gathering, the entire plant is removed. The large plants are selected first and the smaller or later ones are thus given room to develop.

The Savoy is the variety most commonly grown.

SQUASH.

There are two types of squashes, the bush varieties and the running varieties. The bush varieties should be planted in hills 4 feet apart each way and the running varieties 8 to 10 feet apart each way. Squashes are prolific, and the supply for the average family will ordinarily be furnished by five or six hills of each sort. Squash seed should not be planted until after danger of frost is over and the soil is quite warm. The cultivation and care of squashes should be the same as that given cucumbers or muskmelons.

Varieties recommended: The varieties of summer squash commonly grown are Pattypan, Summer Crookneck, and Vegetable Marrow. Of the winter squashes the Hubbard and Golden Hubbard are among the best.

TOMATOES.

To get a crop of early tomatoes the seed should be started about eight weeks before time for setting the plants in the field. In the South the plants can be grown in coldframes covered with canvas or cotton cloth, but in the North a hotbed should be employed. When only a few plants are needed the seed may be sown in a shallow box in the house. For the best results in growing tomatoes the young plants should be transplanted as soon as they reach a height of 1½ to 2 inches. Transplant them to stand 2 inches apart each way in a hotbed, coldframe, or box in the house. When the plants begin to crowd, it is a good plan to transplant them to flower pots, plant bands, old strawberry boxes, or tin cans from which the bottoms and tops have been melted.

Tomato plants should be set in the open as soon as danger of frost has passed. If the plants are to be pruned to one or two stems and tied to stakes, they should be set 18 inches apart in rows 3 feet apart. If the plants are not pruned or staked, they may be planted 3 feet apart in rows 4 feet apart. It is advisable, however, to prune and train to stakes, especially for the early crop, as plants so treated will be healthier and more easily cultivated and will produce fruit which is earlier and more uniform in size and shape than that produced by plants which have not been trained and pruned. Soon after setting the plants in the field a stake should be driven near each plant, to which it may be tied. Care should be exercised to tie the plant so that it will not be injured by the string. A good plan is to loop the string around the stake and tie it under a leaf stem. Go over the patch once every week or ten days and remove all shoots starting in the axils of the leaves.

Varieties recommended: For early tomatoes, Earliana or Chalk's Early Jewel is recommended, preferably the former. For medium and late varieties, the following are suggested: Greater Baltimore, Red Rock, Globe, Beauty, Acme, and Stone. The Stone is usually preferred for canning.

TURNIPS.

The turnip should be grown both as a spring and as a fall crop. For the spring crop, plant as early as the condition of the soil will permit, and for the fall crop sow the seed in late summer or early autumn. Sow the seed thickly in rows 15 to 18 inches apart, and as the plants reach a height of 4 or 5 inches begin thinning, using the young plants for greens. For good roots thin the plants to about 3 inches apart in the row. Cultivate turnips the same as carrots and parsnips. Turnips may be left in the ground until needed for the table, pulled and stored in a cellar, or buried in banks or pits.

Varieties recommended: Purple-Top Globe, White Globe, Seven Top, White Milan, and Yellow Aberdeen.

Rutabaga.—Rutabagas may be grown as a fall and winter crop to very good advantage. They are planted the same as turnips, except that they require more room and a longer period of growth.

The Purple Top is the most common variety of rutabaga.

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THE FARM GARDEN IN THE NORTH

JAMES H. BEATTIE

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FARMERS' BULLETIN 937

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry

WM. A. TAYLOR, Chief

Washington, D. C. February, 1918

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A HALF-ACRE GARDEN, if properly cared for, will produce sufficient vegetables for the average family's use during the summer and for storing, canning, and drying for winter use.

For many vegetables which deteriorate rapidly after being gathered, the only practicable means of securing the best is to grow them at home. This is especially true of garden peas, sweet corn, string beans, Lima beans, and asparagus.

A half-acre garden, well cared for, will produce a far greater return per acre than can be realized from an equal area devoted to general farm crops.

A liberal supply of vegetables, properly prepared and well served, will be found not only nutritious and healthful but economical.

Suitable dates for planting vegetables in different sections have been determined by zones based on the average date of the last killing frost in spring and the first killing frost in autumn.

Specific directions are given for the planting, care, and cultivation of the various vegetables.

THE FARM GARDEN IN THE NORTH.

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DESIRABILITY OF A FARM GARDEN.

A HALF-ACRE GARDEN, if well planned and cared for properly, will produce far more vegetables than the average family can consume during the maturing period of the crops. Beets, late cabbage, carrots, celery, onions, parsnips, potatoes, sweet potatoes, salsify, and turnips may be grown and stored for winter use. The half acre will produce vegetables which, if purchased in the market, would exceed $100 or even $200 in cost. Not only is it possible to reduce the cost of the family's food materially by taking advantage of the possibilities of the home garden, but the satisfaction of having a supply of fresh vegetables near at hand, so that, regardless of market conditions, the list may be varied, is something that can not be measured in dollars and cents. Fresh vegetables from the home garden are not subjected to the deterioration which supplies purchased in the markets suffer and are not liable to become infected, either there or during transportation. Many vegetables lose their characteristic flavor when not used within a few hours after gathering, but can always be had fresh if grown at home. By means of the home garden the production of the vegetable supply for the family is directly under control, and in many cases this is the only way to secure fresh produce.

LOCATION OF THE GARDEN.

While successful gardens are grown on all kinds of soils from light sands to mucks and heavy clays, soil in good tilth and well supplied with plant food is essential to the production of a successful garden. It is often possible to select a site with soil that will yield better results with less labor than near-by plats with less favorable soils. Good soil is essential to a successful garden. If the soil on the selected garden site is poor, it must be put into good condition before satisfactory results can be expected. Even where the soil is good to start with, it will be necessary to spend considerable time in improving it by cultivation and fertilization before it is in first-class condition for the production of vegetables.

A sandy loam is an excellent type of garden soil. Sandy soils, as a rule, warm up earlier than others in the spring and enable the gardener to plant his crops early. Soils too sandy dry out very rapidly and the crops are liable to suffer from drought.

The lay of the land has considerable influence upon the time when the soil can be worked, and a gentle slope toward the south or southeast is most desirable for the production of early crops. It is an advantage to have on the north and northeast a hill, a group of trees, some evergreens, a hedge, buildings, a tight board fence, or a stone wall in order to break the force of the wind.

Good drainage of the garden area is of prime importance. If this does not exist naturally it may be supplied by tillage or by artificial drains. The surface of the land should have sufficient fall to drain off surplus water during heavy rains, but the fall should not be so great that the soil will be washed. On hillsides washing can be overcome to a considerable extent by contouring the rows so as to cause the rains to run off slowly. The garden should not contain depressions in which water will accumulate or stand. If the surface is irregular a little soil can be taken from high places and the low ones filled. Waste water from surrounding land should not flow toward the garden, and the fall below should be such that there will be no danger of flood water backing up. A garden site on the banks of a creek or stream that will be liable to overflow during the growing season should not be selected if any other can be had.

A good fence around the garden plat is almost indispensable. It should protect the crops from all farm animals, including poultry, and should be tight enough to keep out rabbits.

PROXIMITY OF THE GARDEN TO THE HOUSE.

The question of proximity to the house is of as great importance in locating the garden as the character and contour of the ground. In every case it should be as near as possible, so that the work of caring for the crops may be done at odd times and the vegetables quickly secured by the housewife. (See the illustration on the title-page.) A kitchen garden located near the kitchen door is a convenience in thousands of homesteads. It is desirable even where a separate larger garden is utilized for the production of the main portion of the vegetable supply for the family.

IMPORTANCE OF SUNLIGHT.

In selecting the location for the garden and in planning the arrangement of the crops, the gardener should understand that no amount of fertilizer, watering, and care will replace sunshine. Careful consideration should be given to how many hours a day any part of the proposed garden space is shaded. As a rule, foliage crops, such as lettuce, kale, and spinach, do fairly well in partial shade, but must have a minimum of three hours of sunshine a day. Plants which ripen fruits, such as the tomato and eggplant, should have a minimum of five hours of sunshine each day.

PLAN AND ARRANGEMENT OF THE GARDEN.

It would be difficult to give a plan or specific arrangement for a garden that would suit all demands. Such a plan must be devised by each individual grower. Suggestive arrangements, however, are here presented, with the idea that they can readily be changed to suit local conditions.

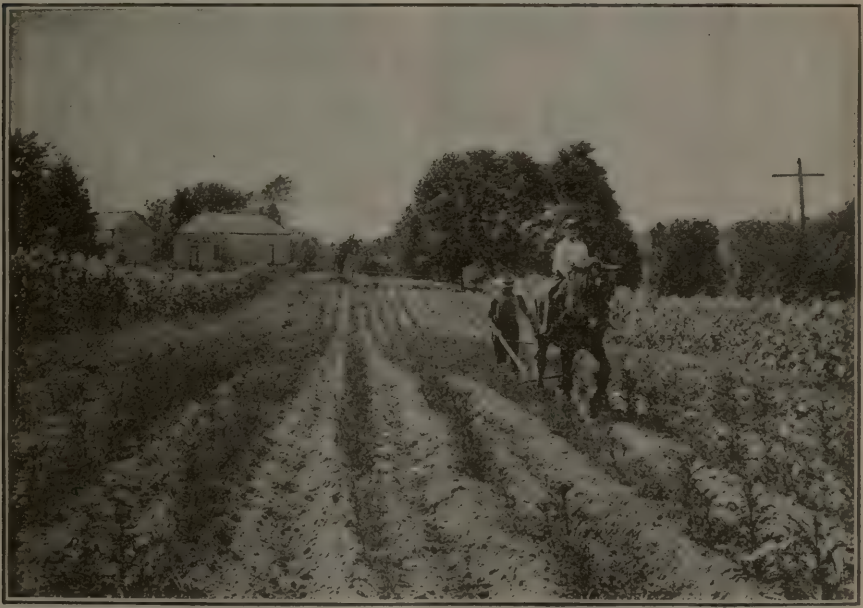

FIG. 1.—When the garden is to be worked by a horse, the rows should be laid out the long way of the garden and should be straight.

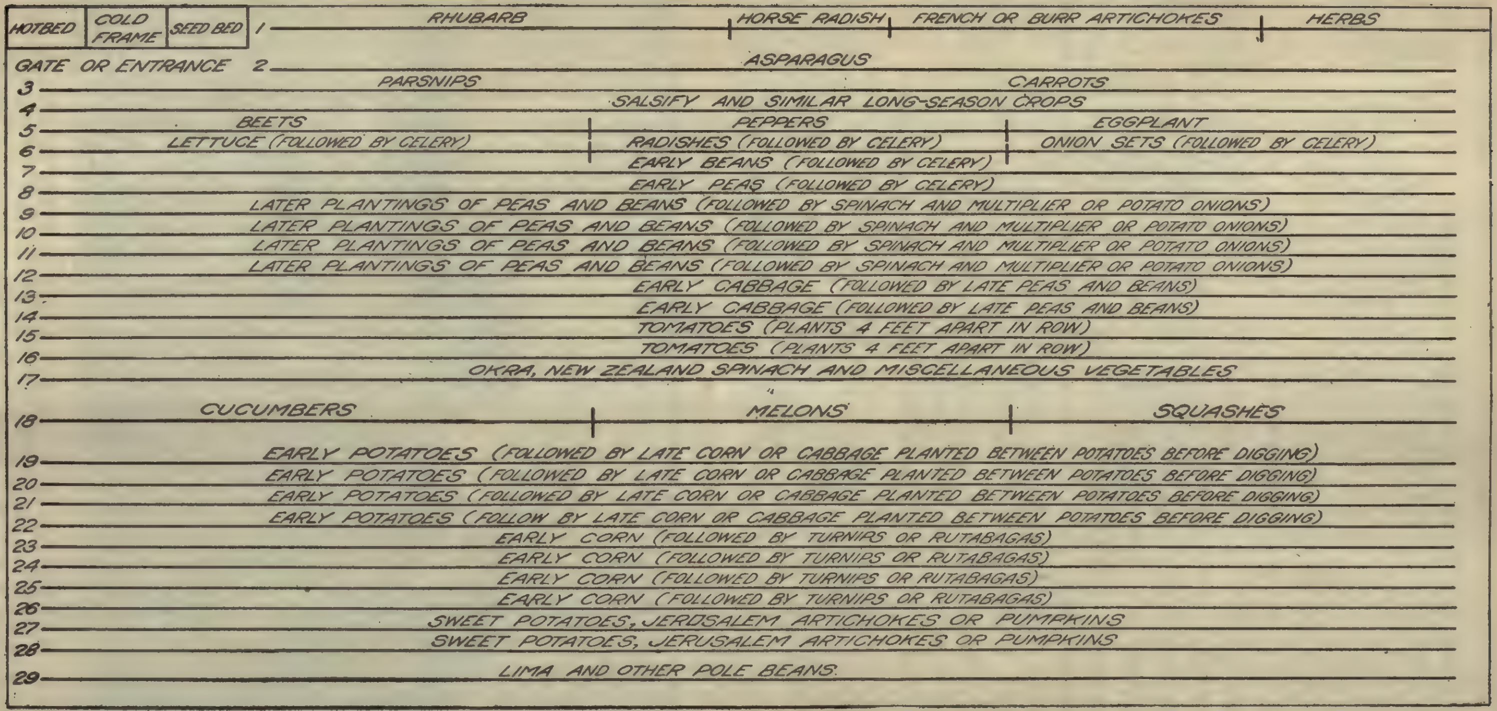
HOTBED
COLD FRAME
SEED BED
1 RHUBARB
HORSE RADISH
FRENCH OR BURR ARTICHOKES
HERBS
GATE OR ENTRANCE
2 ASPARAGUS
3 PARSNIPS
CARROTS
4 SALSIFY AND SIMILAR LONG-SEASON CROPS
5 BEETS
PEPPERS
EGGPLANT
6 LETTUCE (FOLLOWED BY CELERY)
RADISHES (FOLLOWED BY CELERY)
ONION SETS (FOLLOWED BY CELERY)
7 EARLY BEANS (FOLLOWED BY CELERY)
8 EARLY PEAS (FOLLOWED BY CELERY)
9 LATER PLANTINGS OF PEAS AND BEANS (FOLLOWED BY SPINACH AND MULTIPLIER OR POTATO ONIONS)
10 LATER PLANTINGS OF PEAS AND BEANS (FOLLOWED BY SPINACH AND MULTIPLIER OR POTATO ONIONS)
11 LATER PLANTINGS OF PEAS AND BEANS (FOLLOWED BY SPINACH AND MULTIPLIER OR POTATO ONIONS)
12 LATER PLANTINGS OF PEAS AND BEANS (FOLLOWED BY SPINACH AND MULTIPLIER OR POTATO ONIONS)
13 EARLY CABBAGE (FOLLOWED BY LATE PEAS AND BEANS)
14 EARLY CABBAGE (FOLLOWED BY LATE PEAS AND BEANS)
15 TOMATOES (PLANTS 4 FEET APART IN ROW)
16 TOMATOES (PLANTS 4 FEET APART IN ROW)
17 OKRA, NEW ZEALAND SPINACH AND MISCELLANEOUS VEGETABLES
18 CUCUMBERS
MELONS
SQUASHES
19 EARLY POTATOES (FOLLOWED BY LATE CORN OR CABBAGE PLANTED BETWEEN POTATOES BEFORE DIGGING)
20 EARLY POTATOES (FOLLOWED BY LATE CORN OR CABBAGE PLANTED BETWEEN POTATOES BEFORE DIGGING)
21 EARLY POTATOES (FOLLOWED BY LATE CORN OR CABBAGE PLANTED BETWEEN POTATOES BEFORE DIGGING)
22 EARLY POTATOES (FOLLOW BY LATE CORN OR CABBAGE PLANTED BETWEEN POTATOES BEFORE DIGGING)
23 EARLY CORN (FOLLOWED BY TURNIPS OR RUTABAGAS)
24 EARLY CORN (FOLLOWED BY TURNIPS OR RUTABAGAS)
25 EARLY CORN (FOLLOWED BY TURNIPS OR RUTABAGAS)
26 EARLY CORN (FOLLOWED BY TURNIPS OR RUTABAGAS)
27 SWEET POTATOES, JERUSALEM ARTICHOKES OR PUMPKINS
28 SWEET POTATOES, JERUSALEM ARTICHOKES OR PUMPKINS
29 LIMA AND OTHER POLE BEANS.

FIG. 2.—Plan of a half-acre garden. Length, 220 feet; width, 100 feet. A half-acre garden will produce all the vegetables the average family can use throughout the growing season and a surplus for canning, storing, and drying.

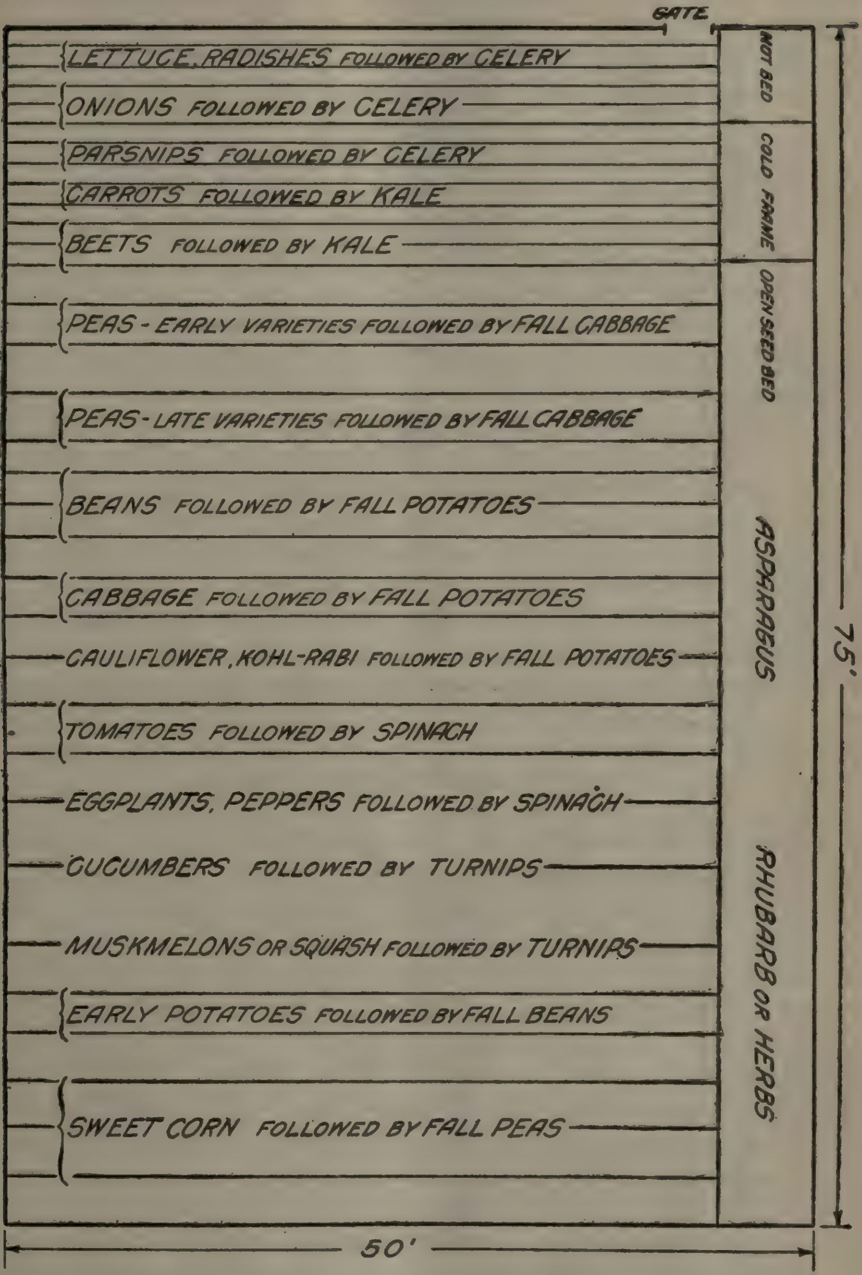
GATE
LETTUCE, RADISHES FOLLOWED BY CELERY
ONIONS FOLLOWED BY CELERY
PARSNIPS FOLLOWED BY CELERY
CARROTS FOLLOWED BY KALE
BEETS FOLLOWED BY KALE
PEAS - EARLY VARIETIES FOLLOWED BY FALL CABBAGE
PEAS - LATE VARIETIES FOLLOWED BY FALL CABBAGE
BEANS FOLLOWED BY FALL POTATOES
CABBAGE FOLLOWED BY FALL POTATOES
CAULIFLOWER, KOHL-RABI FOLLOWED BY FALL POTATOES
TOMATOES FOLLOWED BY SPINACH
EGGPLANTS, PEPPERS FOLLOWED BY SPINACH
CUCUMBERS FOLLOWED BY TURNIPS
MUSKMELONS OR SQUASH FOLLOWED BY TURNIPS
EARLY POTATOES FOLLOWED BY FALL BEANS
SWEET CORN FOLLOWED BY FALL PEAS
HOT BED
COLD FRAME
OPEN SEED BED
ASPARAGUS
RHUBARB OR HERBS
75'
50'

FIG. 3.—Plan of a town or city garden. Length, 75 feet; width, 50 feet. For hand cultivation, the rows may be laid out the short way of the garden and the turning spaces at the ends may be omitted.

The first consideration in planning the arrangement of a garden is the kind of cultivation that is to be employed. When the work is to be done mainly by means of horse tools the site and the arrangement should be such as to give the longest possible rows, and straight lines should be followed. (Fig. 1.) The garden should be free from paths across the rows, and turning spaces should be provided at the ends. (Fig. 2.) For hand cultivation the arrangement can be quite different, as the garden may be laid off in sections, with transverse walks, and the rows for most crops may be much closer. (Fig. 3.) Horse cultivation is recommended whenever possible, as it very materially lessens the labor and cost of caring for the crops.

An important consideration is the location of permanent crops, such as asparagus and rhubarb. If any of the small fruits, such as raspberries, currants, and gooseberries, are to be planted within the garden inclosure, they should be included with the permanent crops. The area devoted to the hotbed, coldframe, and seed bed should be decided upon, but these may be shifted more or less from year to year or located in some convenient place outside of the garden.

Where there is any great variation in the composition of the soil in different parts of the garden it will be advisable to take this into consideration when arranging for the location of the various crops. If a part of the land is low and moist, such crops as celery, onions, and late cucumbers should be placed there. If part of the soil is high, warm, and dry, there is the proper location for early crops and those that need quick, warm soil.

PREPARATION OF THE SOIL.

Autumn is the time for plowing hard or stiff clay soils, as the action of the frost during the winter will break the soil into fine particles and render it suitable for planting. Sandy loams and soils that contain a large amount of humus may be plowed in the spring, but the work should be done early, in order that the soil may settle before planting. Whatever the type of soil, at least a portion of the garden should be plowed in the autumn, so that early crops may be planted as soon as possible in the spring. Plowed ground dries out quicker than unplowed, and by plowing in the fall it is possible to get such crops as peas, beets, and early potatoes planted much earlier than otherwise would be the case.

Sandy soils will bear plowing much earlier than heavy clay soils. The usual test is to squeeze together a handful, and if the soil adheres in a ball it is too wet for working. In the garden, greater depth of plowing should be practiced than for ordinary farm crops, as the roots of many of the vegetables go deeply into the soil. Subsoiling will be found advantageous in most cases, as the drainage and general movement of the soil moisture will be improved thereby.

Hand spading should be resorted to only in very small gardens or where it is desirable to prepare a small area very thoroughly.

After plowing or spading, the next step is to smooth and pulverize the soil. If the soil is well prepared before planting the work of caring for the crops will be materially lessened and better crops will be secured. It is not sufficient that the land be smooth on top. but the pulverizing process should extend as deep as the plowing. Some gardeners follow the practice of disking the soil before plowing, so that when it is turned the bottom soil will be fine and mellow. After the plow, the disk or cutting harrow is again brought into play and the pulverizing process completed. If the soil is a trifle too dry and contains lumps, it may be necessary to use some form of roller or clod crusher to put it in proper condition. For smoothing the surface and filling up depressions, a float or drag made from planks or scantlings will be found serviceable.

MANURES AND FERTILIZERS.

The soil for vegetable growing should be rich and well supplied with humus. Barnyard or stable manure is the best, because it furnishes both plant food and humus. An application of 20 to 30 tons of such manure to the acre is very satisfactory, and on some soils this application will need but little reenforcing with commercial fertilizers. The manure should be applied far enough in advance of planting time to allow it to decay. If coarse manure is used, it should be applied in the fall and turned under, but well-rotted manure should be applied after plowing and should be well mixed with the soil by harrowing.

Where manure is not available, some leguminous crop, such as cowpeas, soy beans, vetch, or crimson clover, should be turned under to supply humus and a part of the nitrogen. In addition to the humus added to the soil through the growth of these crops the cultivation necessitated by their growth tends to make available some fertilizing elements, especially potash. The use of commercial fertilizers is advisable in many cases, but owing to the high cost of nitrogen and potash in commercial fertilizers they should be used only if necessary as a supplement to the nitrogen to be secured through the use of leguminous crops and stable manure and the potash made available in many soils by intelligent cultivation.

Phosphates are relatively inexpensive and their use is advisable in most cases. They are especially valuable in that they aid in bringing the crops to maturity. An application of 300 to 600 pounds of acid phosphate to the acre will be sufficient.

No definite rule can be given for the kind or quantity of mixed fertilizer to be applied, as this varies with the crop and soil. In most cases it is safe to apply 1,000 to 2,000 pounds of a high-grade fertilizer to the acre. One analyzing 2 to 4 per cent nitrogen, 8 per cent phosphoric acid, and 6 to 8 per cent potash should give good results if the soil is well supplied with humus. This fertilizer may be secured already prepared or may be mixed at home. The following combination will make a satisfactory fertilizer for a home garden and may be applied at the rate of 1,000 to 2,000 pounds to the acre:

150 pounds of nitrate of soda.
650 pounds of cottonseed meal.
1,000 pounds of acid phosphate, 16 per cent.
200 pounds of muriate or sulphate of potash.

It should be borne in mind that commercial fertilizers will not produce satisfactory results unless the soil is well supplied with humus. In fact, large quantities of fertilizers are justified only where the soil is in good mechanical condition.

Owing to the scarcity and high price of both nitrogen and potash fertilizers, a very satisfactory substitute may be had by using chicken or pigeon manure, acid phosphate, and hardwood ashes. The following quantities per acre will make a satisfactory application:

3 tons of chicken or pigeon manure.
1,000 pounds of acid phosphate.
1,000 pounds of hardwood ashes.

The acid phosphate and hardwood ashes may be mixed and applied either by hand or with a fertilizer drill. The manure, however, should be applied separately, as mixing it with the other ingredients will cause a loss of nitrogen. This fertilizer should be used as suggested for the previous formula. It should be remembered, however, that this kind of manure is very strong and liable to cause injury to the plants if applied in direct contact with the roots. It should be applied and worked into the soil before the garden is planted, or, if used after planting, should be applied between the rows a few inches from the plants.

The use of lime is advisable on heavy soils, especially when green manures and cover crops are employed to add humus to the soil. Lime should not be applied at the same time as either stable manure or mixed fertilizer, as it will under those circumstances cause the loss of nitrogen.

Lime may be applied in the form of ground lime (calcium oxid), ground limestone (calcium carbonate), or air-slaked lime, which is in most cases a mixture of calcium hydroxid and calcium carbonate. Ground limestone acts slower than burned lime, but is satisfactory. When the ground freshly burned lime is applied, it should be used at half the rate of the air-slaked lime or the ground limestone. From 5 to 10 pounds of the ground limestone and half this quantity of the ground burned lime is a sufficient application for each 100 square feet of soil.

SEEDS AND PLANTS FOR THE GARDEN.

Vegetable seeds should be ordered in advance of the time for planting in the open, so that they will be on hand in time for planting in flats or frames and also for use outdoors as soon as the weather and the condition of the soil make planting possible. Before ordering seed, it is a good idea to look over the garden plat, decide on the best location for each vegetable, and determine how much seed will be required for the space available for each variety. The garden plan may then be drawn.

Make the seed supply produce 100 per cent of efficiency. Estimate the needs carefully. Order what you need and no more. Make the best possible use of what is obtained. Wasteful practices on your part may deprive a neighbor of a needed supply.

SEED FOR A FAMILY OF FOUR.

The following are the approximate quantities of seed that should be purchased for a garden which is to supply vegetables for successive plantings throughout the season for a family of four:

Beans:		Lettuce	½ ounce.
Bush Lima	1 pint.	Muskmelon	1 ounce.
Pole Lima	1 pint.	Onion sets	4 to 6 quarts.
Snap	1 to 2 quarts.	Peas	2 to 4 quarts.
Beets	4 ounces.	Parsley	1 packet.
Cabbage:		Parsnips	½ ounce.
Early	1 packet.	Radish	1 ounce.
Late	½ ounce.	Salsify	1 ounce.
Carrot	1 ounce.	Spinach	½ pound.
Cauliflower	1 packet.	Squash, summer	1 ounce.
Celery	1 packet.	Tomatoes:	
Corn, sweet	1 to 2 pints.	Early	1 packet.
Cucumbers	1 ounce.	Late	¼ ounce.
Eggplant	1 packet.	Turnips	2 to 3 ounces.
Kale	2 ounces.	Watermelon	2 ounces.

The quantity of seed specified should produce sufficient vegetables to supply the needs of the family during the growing season, as well as to supply a surplus for canning, drying, and storage.

The entire supply of seeds of string beans, bush Lima beans, sweet corn, lettuce, peas, and radish should not be planted at one time, but successive plantings, 10 days to two or three weeks apart, should be made, so that a fresh supply of vegetables may be had through the season.

AIDS TO EARLINESS.

The hotbed, the "flat" or seed box, and the coldframe are the gardener's greatest aids in raising early crops. The hotbed and the

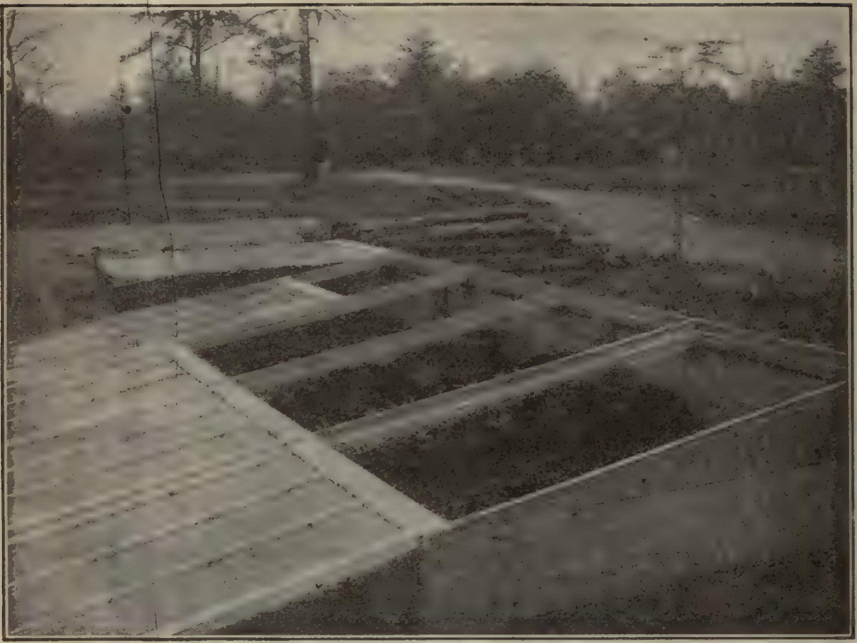

FIG. 4.—A good type of hotbed suitable for a home garden. The frame is of 1-inch boards and the sash are 3 feet wide and 6 feet long. A slope of 6 inches is sufficient to cause the water to run off.

flat enable him to plant seed and produce seedlings long before most of the seeds can be planted out of doors and before those which have been so planted have begun to germinate.

EARLY PLANTS IN HOTBEDS.

The common method of starting early plants in the North is by means of a hotbed. The hotbed consists of an inclosure covered with sash and supplied with some form of heat, usually fermenting stable manure, to keep the plants warm and in a growing condition.

An inexpensive type of hotbed is shown in figure 4. As a rule the hotbed should not be placed within the garden inclosure, but near some frequently used path or building, where it can receive attention without interfering with other work. The hotbed should always face the south, and the south side of a dwelling, barn, tight board fence, hedge, or anything affording similar protection will furnish a good location.

In the North the hotbed should be started in February or early in March, in order that the plants may be well grown in time to plant in the open ground. In planning the hotbed, provision should be made for starting early cabbage, tomato, pepper, eggplant, lettuce, sweet potatoes, onions, and, if so desired, Lima beans, cucumbers, squash, and melons, in baskets, on sods, or in dirt bands. There are two or three forms of hotbeds that are worthy of description, and the plans may be modified to suit local conditions.

A temporary hotbed, such as would ordinarily be employed on the farm, is easily constructed by the use of manure from the horse stable as a means of furnishing the heat. Select a well-drained location, where the bed will be sheltered, shake out the manure into a broad, flat heap, and thoroughly compact it by trampling. The manure heap should be 8 or 9 feet wide, 18 to 24 inches deep when compacted, and may be of any desired length, according to the number of sash to be employed. The manure for hotbed purposes should contain sufficient litter, such as leaves or straw, to prevent its packing soggy, and should spring slightly when trodden upon.

After the manure has been properly trampled and leveled, the frames to support the sash are placed in position, facing toward the south. These frames are generally made to carry four standard hotbed sash, and the front board should be 4 to 6 inches lower than the back, in order that water will drain from the glass. From 3 to 5 inches of good garden loam or specially prepared soil is spread evenly over the area inclosed by the frame, the sash is put on, and the bed allowed to heat. At first, the temperature of the bed will run quite high, but no seeds should be planted until the soil temperature falls to 80° F., which will be in about three days.

Hotbeds having more or less permanence may be so constructed as to be heated either with fermenting manure, a stove, a brick flue, or by means of radiating pipes supplied with steam or hot water from a heating plant. For a permanent bed in which fermenting manure is to supply the heat, a pit 24 to 30 inches in depth should be provided. The sides and ends of the pit may be supported by brick walls or by a lining of 2-inch plank held in place by stakes.

Standard hotbed sash are 3 by 6 feet in size, and are usually constructed of white pine or cypress. As a rule, hotbed sash are on sale by seedsmen and dealers in garden supplies and can be purchased more cheaply than they can be made locally. In the colder parts of the country, in addition to glazed sash, either board shutters, straw mats, burlap, or old carpet will be required as a covering during cold nights. It is also desirable to have a supply of straw or loose manure on hand, to throw over the bed in case of extremely cold weather.

During bright days the hotbed will heat very quickly from the sunshine on the glass, and it will be necessary to ventilate during the early morning by slightly raising the sash on the side opposite from the wind. Care should be taken in ventilating to protect the plants from a draft of cold air. Toward evening the sash should be closed, in order that the bed may become sufficiently warm before nightfall.

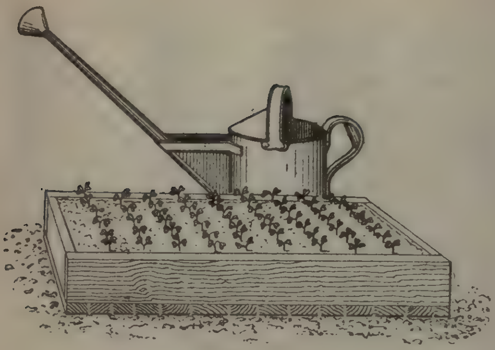

FIG. 5.

Hotbeds should be watered on bright days and in the morning only. Watering in the evening or on cloudy days will have a tendency to chill the bed and increase the danger from freezing. After watering, the bed should be well ventilated, in order to dry the foliage of the plants and the surface of the soil to prevent the plants being lost by damping-off or mildew.

EARLY PLANTS IN COLDFRAMES.

Coldframes are constructed like temporary hotbeds except that no manure or other heating material is provided. Coldframes are covered with ordinary hotbed sash, or cotton cloth may be substituted for the sash. In the colder sections of the North, the coldframe is used for hardening off the plants that have been started in the hotbed, preparatory to setting them in the garden. In parts of zones D and E the coldframe is used for growing winter lettuce, spinach, etc. The same methods of handling recommended for a hotbed should apply to a coldframe, and thorough ventilation should be maintained.

THE SEED BED.

It is a good practice to reserve a small corner of the garden for a seed bed. Here, through special preparation of the soil it is possible

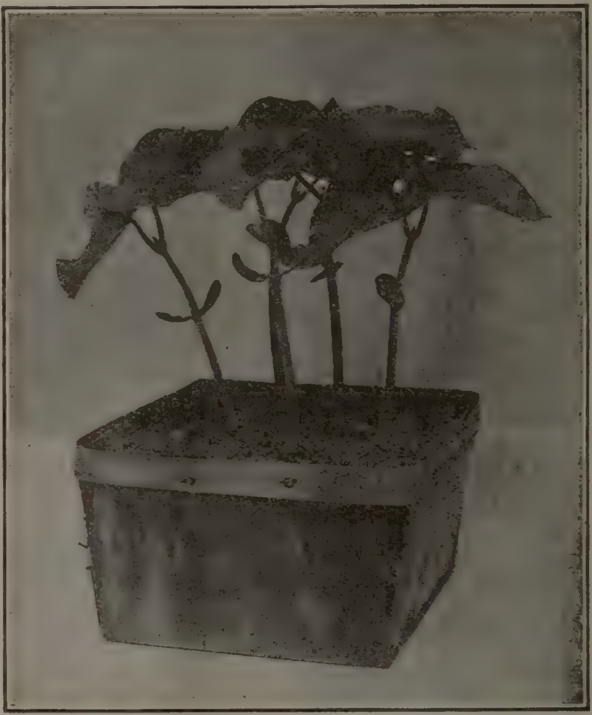

FIG. 6.—A hill of beans started in a berry box in the house long before the seeds could be planted in the open ground.

to produce better plants than could otherwise be secured. The gardener can transplant from the seed bed to the garden, thus making the plants more stocky. The location of an outdoor seed bed should be such that it may be conveniently reached for watering, and it should be naturally protected from drying winds.

Good soil for a seed bed consists of one part of well-rotted manure, two parts of good garden loam or rotted sods, and one part of sharp, fine sand. The manure should be thoroughly rotted, but it should not have been exposed to the weather and the strength leached out of it. The addition of leaf mold or peat will tend to make the soil better adapted for seed-bed purposes. Mix all the ingredients together in a heap, stirring well with a shovel, after which the soil should be sifted and placed in boxes or in the bed ready for sowing the seed.

SEED SOWING.

Garden seeds should always be sown in straight rows regardless of where the planting is made. If a flat (fig. 5) or a window box is employed for starting early plants in a dwelling, the soil should be well firmed and then laid off in straight rows about 2 inches apart. The same method holds good for planting seeds in a hotbed, coldframe, or bed in the garden, except that the rows should be farther apart than in the window box. By planting in straight rows the seedlings will be more uniform in size and shape, and thinning and cultivating will be more easily accomplished. In all cases where the soil of the seed bed is not too wet, it should be well firmed or pressed down before laying off and marking for sowing the seeds. After the seeds are sown and covered, the surface should again be firmed by means of a smooth board. Lima beans, melons, cucumbers, and other garden crops may be started in berry baskets, on sod, or in paper bands indoors and the whole transferred to the garden when the weather permits, thus gaining considerable time. (Fig. 6.) Thirty to fifty hills of extra-early potatoes may even be had by starting as many seed pieces in a box in the living room or in a hotbed and subsequently handling the plants the same as tomato plants.

DEPTH OF PLANTING AND DISTANCE APART.

No general rule can be given with regard to depth of planting, as different kinds of vegetables and different soils necessitate different practices. The smaller the seeds the shallower the covering should be. In heavy soils the covering should be lighter than in light soils. The following table gives the depth of planting of the various vegetable seeds, as well as the quantity of seeds or number of plants required for 100 feet of row and the distance apart for the rows and the plants in the rows.

GARDENERS' PLANTING TABLE.

Quantity of seeds and number of plants required for 100 feet of row, depths of planting, and distances apart for rows and plants.

Kind of vegetable.	Required for 100 feet of row.		Depth for planting seed.	Distance apart.		
	Seed.	Plants.		Rows.		Plants in the row.
				Horse cultivation.	Hand cultivation.	
			Inches.	*Feet.*		
Asparagus	1 ounce	60 to 80	1 to 1½	3 to 4	2 feet	15 inches.
Bean:						
Bush	1 pint		1½ to 2	2½ to 3	2 feet	3 to 4 inches.
Bush Lima	½ to 1 pint		1½ to 2	3	2½ feet	6 to 10 inches.
Pole Lima	½ pint		1½ to 2	4	3 feet	3 to 4 feet.
Beet	2 ounces		1 to 1½	2 to 2½	15 to 18 inches.	4 to 5 inches.
Cabbage	½ ounce	65 to 90	½	2½ to 3	2 to 2½ feet	14 to 18 inches.
Carrot	1 ounce		½	2 to 2½	15 to 18 inches.	3 to 4 inches.
Cauliflower	⅛ ounce	60 to 75	½	2½ to 3	2 to 2½ feet	15 to 18 inches.
Celery	do	200 to 250	⅛	3 to 4	18 to 24 inches.	4 to 6 inches.
Collard	¼ ounce	65 to 100	½	2 to 2½	do	12 to 18 inches.
Corn, sweet	¼ pint		2	3 to 3½	2½ to 3 feet	10 to 12 inches.
Cucumber	½ ounce		1 to 1½	4 to 5	4 to 5 feet	15 inches.
Eggplant	¼ ounce	50 to 70	½	3	2 to 2½ feet	18 to 24 inches.
Kale	½ ounce		½	2½ to 3	18 to 24 inches.	8 to 10 inches.
Lettuce	do	125 to 200	½	2 to 2½	15 to 18 inches.	6 to 10 inches.
Melon:						
Muskmelon	do		1 to 1½	5 to 6	5 to 6 feet	Drills, 18 inches. Hills, 5 feet.
Watermelon	1 ounce		1 to 2	8 to 10	8 to 10 feet	Drills, 2 to 3 feet. Hills, 8 feet.
Okra	2 ounces		1 to 2	4	3 feet	2 feet.
Onions:						
Seed	1 ounce		½ to 1	2	15 inches	3 to 4 inches.
Sets	1 quart		1 to 2	2	do	Do.
Parsley	¼ ounce		⅛	2	do	Do.
Parsnips	½ ounce		½ to 1	2 to 2½	15 to 18 inches.	Do.
Pea	1 to 2 pints		2 to 3	3 to 4	2½ to 3 feet	1 inch.
Potato:						
Irish	5 to 6 pounds		4	2½ to 3	2 to 2½ feet	12 to 18 inches.
Sweet	3 pounds	75 (slips).	2 to 3	4 to 5	4 to 5 feet	14 to 18 inches.
Radish	1 ounce		½ to 1	2	12 to 15 inches.	1 inch.
Salsify	do		½ to 1	2	15 to 18 inches.	Do.
Spinach	do		1 to 2	2	do	1 to 2 inches.
Squash:						
Bush	½ ounce		1 to 2	3 to 4	3 to 4 feet	Drills, 15 to 18 inches. Hills, 4 feet.
Vine	do		1 to 2	7 to 10	7 to 10 feet	Drills, 2 to 3 feet. Hills, 8 feet.
Tomato	⅛ ounce	35 to 50	½ to 1	3 to 4	2 to 3 feet	2 to 3 feet.
Turnip	½ ounce		¼ to ½	2	15 to 18 inches.	2 to 3 inches.

The seed bed should never be allowed to become dry, but great care should be taken that too much water is not applied. Plants require the action of air upon their roots, and an excess of water in the soil will exclude the air. Too frequent and heavy waterings will cause the damping-off of the seedlings.

TRANSPLANTING.

For the best results, plants started in boxes, hotbeds, or coldframes should be transplanted when they reach a height of 1 to 2 inches. Transplanting tends to produce uniform stocky plants with a well-developed root system. The seedlings may be transplanted to boxes or to the hotbed or coldframe, to stand about 2 inches apart each way. Some growers transplant twice before setting in the open ground. Figure 7 shows two celery plants from the same seeding. The one at the left was transplanted, while that at the right was allowed to remain in the seed bed until time for planting in the garden.

HARDENING OFF.

Plants grown in a house, hotbed, or coldframe should be hardened off before they are transplanted to the garden. This can be accomplished by ventilation and exposure to outdoor conditions during the day in good weather. If the plants are in a hotbed or coldframe, the covers may be removed during the day when the weather is good and replaced toward nightfall. After danger of frosts is past the covers may be left off at night. By the time the plants are large enough to be transplanted to the garden, they should be thoroughly accustomed to outdoor conditions. Such plants usually withstand the transfer to the garden with little check and few losses.

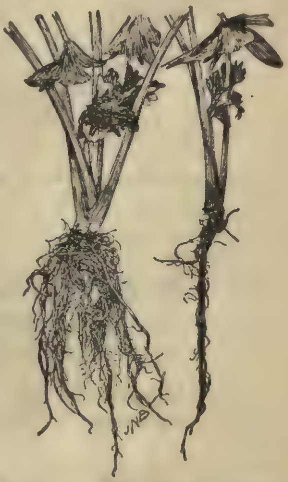

FIG. 7.—Two celery plants; one transplanted, the other from the original seed bed.

SETTING PLANTS IN THE OPEN GROUND.

Before plants are taken for transplanting, the bed should be thoroughly watered and the water allowed to soak into the ground. This will insure a portion of the soil adhering to the roots and will prevent serious wilting or the checking of growth. Take up the plants with a trowel or spade and pack them in the boxes or baskets in which they are to be carried in the field.

The land should be in good condition and everything should be ready for quick operation when planting time arrives. Mark off the rows or dig holes for the plants just before planting, in order to prevent the drying of the soil. If possible, set the plants on a cloudy day or just before nightfall. When the soil is very dry it is advisable to use a little water in the holes. The water should be applied when the hole is partly filled with soil, and the moist earth should then be covered with dry soil, to prevent baking.

TIME OF PLANTING.

Garden crops may be divided into four groups, the first including those crops that may be planted before the date of the last killing

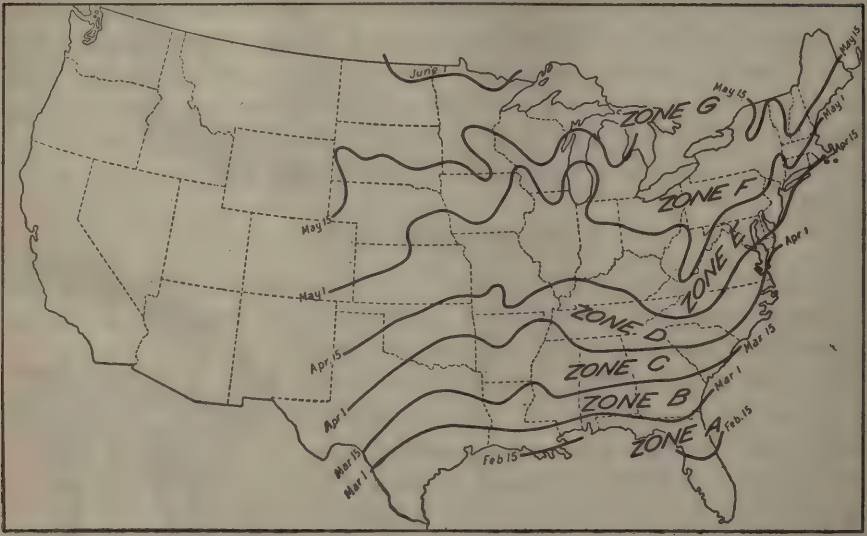

FIG. 8.—A zone map of the United States, based on the average dates of the latest killing frost in spring.

frost in the spring, the second group those that may be planted about the time of the last killing frost, the third including those crops that can not be planted until all danger of frost is past and the ground has warmed up somewhat, and the fourth, heat-loving plants that can not be planted until the weather is hot.

PLANTING ZONES FOR THE EASTERN UNITED STATES.

Most gardeners are interested in knowing the earliest date for planting the various crops, as earliness is much desired. It has been found that the earliest safe dates for planting garden crops can be determined from the average dates of the last killing frost in spring. The map (fig. 8) shows the continental portion of the United States divided into zones, with a difference of about two weeks in the average date of the last killing frost. The average dates of the last killing frost furnish a guide in planting which is reasonably safe, though it can not be depended upon every year. There is a difference of several days within the zones themselves, owing to differences in elevation, in latitude, and in proximity to bodies of water. The table gives the planting dates for the four zones comprising that portion of the United States covered by this bulletin.

TIME OF PLANTING VEGETABLE SEEDS.

Earliest safe dates for planting vegetable seeds in the open in the zones of the United States illustrated in figure 8.

Crop.	Zone D.	Zone E.	Zone F.	Zone G.
Asparagus	Mar. 15 to Apr. 15.	Apr. 15 to May 1	May 1 to 15	May 1 to June 1.
Artichoke:				
Globe	Apr. 15 to May 15	May 1 to 30	(Not grown)	(Not grown.)
Jerusalem	Mar. 15 to Apr. 1	Apr. 1 to 15	do	Do.
Beans:				
Snap	Apr. 1 to May 1	May 1 to 15	May 15 to June 1	May 15 to June 15.
Lima	May 1 to 15	May 15 to June 1	May 15 to June 15.	
Beets	Mar. 15 to Apr. 15.	Apr. 15 to May 1	May 1 to 15	May 15 to June 1.
Brussels sprouts	do	do	do	Do.
Broccoli	do	do	do	Do.
Cabbage	Mar. 1 to 15	Mar. 15 to Apr. 15.	Apr. 15 to May 1	May 1 to May 15.
Carrots	Mar. 15 to Apr. 15.	Apr. 15 to May 1	May 1 to 15	May 1 to June 1.
Cauliflower	do	do	do	Do.
Celery	do	do	do	Do.
Chard	do	do	do	Do.
Collards	Mar. 1 to 15	Mar. 15 to Apr. 15.		
Corn, sweet	Apr. 1 to May 1	Apr. 15 to May 15.	May 1 to June 1	May 15 to June 15.
Cucumbers	Apr. 15 to May 1	May 1 to June 1	May 15 to June 15.	June 1 to 15.
Eggplant	do	do	do	(Season too short.)
Garlic	Mar. 1 to 15	Mar. 15 to Apr. 15.	Apr. 15 to May 1	May 1 to 15.
Kale	do	do	do	Do.
Kohl-rabi	Mar. 15 to Apr. 1	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Lettuce:				
Head	Mar. 15 to Apr. 15.	do	do	Do.
Leaf	Mar. 1 to 15	Mar. 15 to Apr. 15.	Apr. 15 to May 1	May 1 to 15.
Melons	Apr. 15 to May 1	May 1 to June 1	June 1 to 15	
Mustard	Mar. 15 to Apr. 1	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Okra, or gumbo	Apr. 15 to May 1	May 1 to 15	May 15 to June 1	June 1 to 15.
Onion:				
Sets	Mar. 1 to 15	Mar. 15 to Apr. 15.	Apr. 15 to May 1	May 1 to 15.
Seeds	Mar. 15 to Apr. 1	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Parsley	do	do	do	Do.
Parsnip	do	do	do	Do.
Peas:				
Smooth	Mar. 1 to 15	Mar. 15 to Apr. 15.	Apr. 15 to May 1	May 1 to June 1.
Wrinkled	Mar. 15 to Apr. 1	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Peppers	Apr. 15 to May 1	May 1 to June 1	June 1 to 15	
Potatoes:				
Irish	Mar. 1 to 15	Mar. 15 to Apr. 15.	Apr. 15 to May 1	May 1 to June 1.
Sweet	Apr. 15 to May 1	May 1 to June 1	June 1 to 15	
Pumpkins	do	do	do	
Radish	Mar. 1 to 15	Mar. 15 to Apr. 15.	Apr. 15 to May 1	May 1 to 15.
Rhubarb	Mar. 15 to Apr. 15.	Apr. 15 to May 1	May 1 to 15	May 15 to June 1.
Salsify	do	do	do	Do.
Spinach	do	do	do	Do.
Squash	Apr. 15 to May 1	May 1 to June 1	June 1 to 15	
Tomatoes	Apr. 15 to May 1	May 1 to June 1	May 15 to June 15.	June 1 to 15.
Turnips	Mar. 1 to 15	Mar. 15 to Apr. 15.	Apr. 15 to May 1	May 1 to 15.

In parts of zone D cabbage, turnips, spinach, and kale will withstand the winter and may be planted in the fall. With protective covering these same crops may be carried through the winter in portions of zone E. Several of the crops listed can not be grown in portions of zones F and G, as the season is either too short or the average temperature too low for the successful development of the crops, this being particularly true of eggplants, sweet potatoes, sweet corn, and melons.

The dates given in the table refer to first plantings. Several plantings should be made of crops that mature in a short time or which are in their prime only a short while. This is especially true of lettuce, radishes, string beans, and peas. Plantings of these should be made at intervals of two or three weeks until the weather becomes too hot or there is no longer time for their development before killing frosts.

PLANTING GUIDE FOR THE WESTERN UNITED STATES.

It is impossible to continue the zone lines west of the Great Plains region, owing to the fact that the western portion of the United States is so broken by rivers and mountain ranges that the average dates of killing frosts vary several weeks within a few miles. In southern California frost occurs at rare intervals, while in northern California frost is liable to occur in any month of the year. The accompanying outline map of the western part of the United States (fig. 9) gives the average dates of the last killing frost in spring, and from this information it is possible to form an idea as to the proper planting time for each crop.

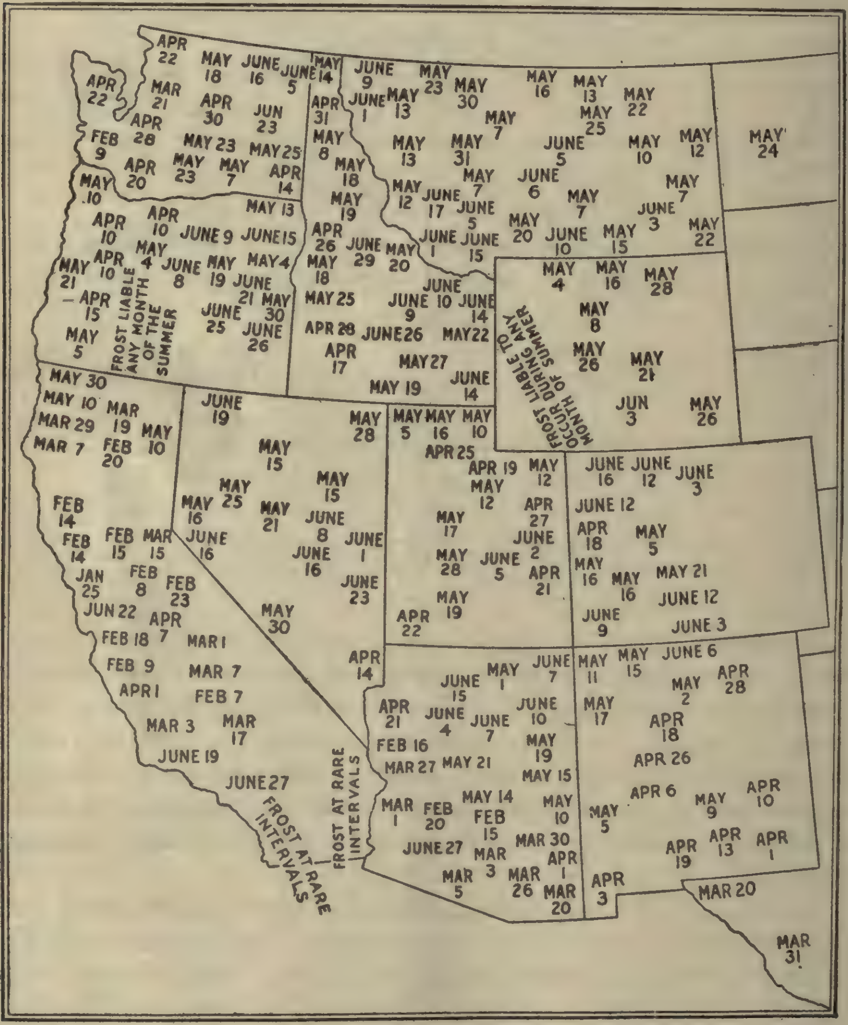

FIG. 9.—Outline map showing the average date of the last killing frost in spring in the western portion of the United States.

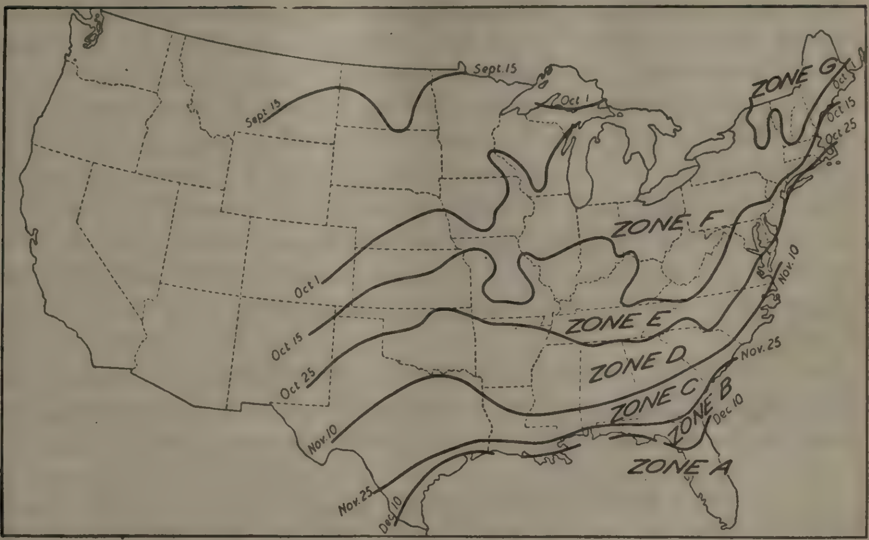

FIG. 10.—A zone map of the United States, based on the average date of the first killing frost in autumn. By referring to the table, the latest safe date for planting any crop in any one of the various zones may be determined.

Beets, early cabbage plants, cauliflower, kale, onion sets, smooth peas, Irish potatoes, and radishes may be planted two weeks before the average date of the last killing frost.

Carrots, lettuce, onion seed, wrinkled peas, spinach, and sweet corn may be planted about the date of the last killing frost.

Beans, salsify, and tomato plants may be planted two weeks after the last killing frost, while the heat-loving plants, such as peppers, eggplants, Lima beans, and squash should not be planted in the open until the ground has warmed up, which will be about four weeks after the last killing frost.

LATEST DATES FOR PLANTING VEGETABLES.

It is advisable to make successive plantings of many crops until they will not have time to mature before killing frosts. The latest safe dates for crops that may be planted in summer so that they will have time to mature before killing frosts is shown on the map (fig. 10) and table (p. 23). Many crops may be planted at frequent intervals throughout the summer until they will no longer have time to mature, as shown by the table and map mentioned. Several crops may be planted later than the dates given but will not mature before winter. Spinach and kale are frequently sown in the fall for spring use.

The dates given allow the crops time to mature and are not necessarily the latest dates for planting several of the crops. Where maturity is not necessary or desired, later plantings may be made. The map (fig. 10) is based on the average dates of the first killing frost in autumn and divides the continental portion of the United

States into zones somewhat different from those employed in the map for the earliest safe dates for planting in the spring. The table (p. 23) shows the latest date on which it is safe to plant the various crops in the different zones so that the crops will have time to mature before killing frosts. In the case of several crops not injured by moderate frost, the dates given do not always permit the crops to mature before frost. In many places it is the custom to plant fall crops for spring use. Among these may be mentioned spinach, kale, and cabbage. The purpose of the map is merely to indicate whether it is possible at a given time to mature certain crops before frost or not.

For the section of the United States west of that included in the zones, figure 11, showing the average dates of the first killing frost

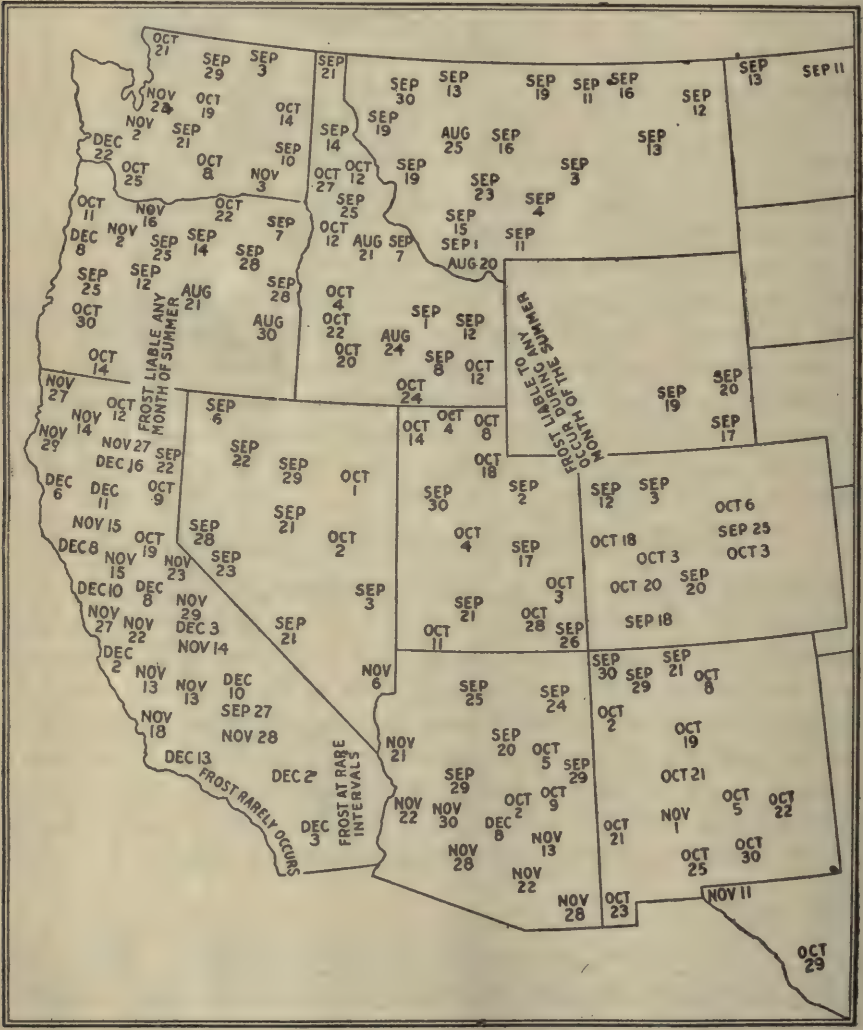

FIG. 11.—Outline map showing the average date of the first killing frost in autumn in the western portion of the United States.

in autumn, is given. The following table shows the approximate period necessary for the maturity of the various garden crops. By counting back, it can be determined whether at any time in the summer there is still time to mature a certain crop or whether the growing season is long enough for that particular crop. Due attention should be paid to the point brought out in a previous paragraph that in many places where the season is apparently long enough for certain crops, they can not be brought to maturity, owing to the fact that the average temperature is too low for their development. This is especially true of eggplants, sweet corn, sweet potatoes, and melons.

TIME OF PLANTING VEGETABLE SEEDS.

Latest safe dates for planting vegetable seeds in the open in the North, based on the average date of the first killing frost.

Crop.	Zone D.	Zone E.	Zone F.	Zone G.	Period necessary for maturity.
Bean:					
Bush	Sept. 1	Aug. 15	Aug. 1	July 15	40 to 65 days.
Bush Lima	Aug. 15	Aug. 1	July 15	....	70 to 90 days.
Pole Lima	Aug. 1	July 15	July 1	....	80 to 120 days.
Beets	Sept. 1	Aug. 15	Aug. 1	July 15	60 to 80 days.
Cabbage, late	Aug. 15	July 15	July 1	June 15	90 to 130 days.
Carrot	...do.....	...do.....	...do.....	...do.....	70 to 100 days.
Cauliflower	...do.....	...do.....	...do.....	...do.....	100 to 130 days.
Celery	Sept. 1	Aug. 1	July 1	May 15	120 to 150 days.
Collard	...do.....	...do.....	...do.....	...do.....	100 to 120 days.
Corn, sweet	Aug. 1	July 15	July 1	June 15	60 to 100 days.
Cucumber	...do.....	...do.....	...do.....	...do.....	60 to 80 days.
Eggplant	July 1	June 15	June 1	....	100 to 140 days.
Kale	Oct. 1	Sept. 15	Sept. 1	Aug. 15	90 to 120 days.
Lettuce	Oct. 15	Oct 1	Sep. 15	Sept. 1	60 to 90 days.
Melon:					
Muskmelon	June 1	May 15	May 1	....	120 to 150 days.
Watermelon	July 1	June 15	....	....	100 to 120 days.
Okra	...do.....	...do.....	June 1	....	90 to 140 days.
Onion:					
Seed	June 1	May 15	May 1	Apr. 15	130 to 150 days.
Sets	July 1	June 15	June 1	May 15	60 to 120 days.
Parsley	Oct. 1	Sept. 1	Aug. 1	July 1	90 to 120 days.
Parsnips	....	May 15	May 1	Apr. 15	125 to 160 days.
Peas	Oct. 1	Sept. 1	Aug. 1	July 15	40 to 80 days.
Pepper	July 1	June 15	June 1	....	100 to 140 days.
Pumpkin	...do.....	...do.....	...do.....	....	Do.
Potato:					
Irish	Aug. 1	July 15	July 1	June 15	80 to 140 days.
Sweet	July 15	June 15	May 1	....	140 to 160 days.
Radish	Oct. 1	Sept. 15	Sept. 1	Aug. 15	20 to 140 days.
Salsify	June 1	May 15	May 1	Apr. 15	120 to 180 days.
Spinach	Oct. 1	Sept. 1	Aug. 15	Aug. 1	30 to 60 days.
Squash:					
Bush	Aug. 1	July 15	July 1	June 15	60 to 80 days.
Vine	July 1	June 15	June 1	....	120 to 160 day.
Tomato	July 15	July 1	June 15	....	80 to 125 days.
Turnip	Oct. 1	Sept. 1	Aug. 1	July 15	60 to 80 days.

SUCCESSION AND ROTATION OF CROPS IN THE GARDEN.

All the ground in the garden should be kept fully occupied all the season. As soon as one crop is removed, something else should take its place. The following grouping of vegetables will serve to indicate which ones may precede or follow others.

Crops occupying the ground all the season.

Beans, pole.
Beans, pole Lima.
Cucumbers.
Eggplant.
Melons.
Okra.
Onions, from seed.
Parsnips.
Pumpkins.
Peppers.
Potatoes, Irish, main crop.
Tomatoes.
Squash.
Potatoes, sweet.

Early crops which may be followed by others.

Beans, bush.
Beets.
Cabbage, early.
Carrots.
Corn, early.
Lettuce.
Peas.
Potatoes, early.
Radish.
Spinach.
Turnips.

Late crops which may follow others.

Beets.
Brussels sprouts.
Cabbage, late.
Cauliflower.
Celery.
Corn, sweet.
Kale.
Peas.
Spinach.
Turnips.

In planning the garden all early-maturing crops should be grouped together, so that after removal the ground will be available as a unit for planting something else. It is not always necessary to wait until the crop is removed. Late cabbage or sweet corn may be planted between the rows of early potatoes some two or three weeks before the potatoes are harvested. Some dissimilar crop should follow the first crop occupying the ground, in order to help in the control of insects and diseases.

CULTIVATION OF GARDEN CROPS.

Frequent shallow cultivation should be given garden crops. By keeping the surface of the soil stirred a dust mulch is formed, which prevents the loss of moisture through the pores in the soil and keeps down the weeds.

The soil should be cultivated as soon as it is dry enough after a rain to break the crust and prevent baking. Sandy soils may be cultivated when quite wet, but clay soils should not be stirred when sticky. Too much emphasis can not be placed on the matter of thorough cultivation. If the work is properly done at the right time there will be little difficulty in controlling weeds.

In cultivating the garden, small-tooth cultivators should be used to prevent ridging or furrowing. Figue 12 shows a good type of horse cultivator for use in the garden. A turn-plow or sweep should not be used for cultivation unless the land becomes so weedy that a cultivator will not do the work. Frequent cultivations

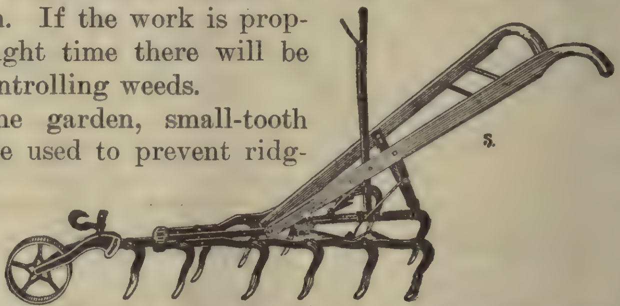

FIG. 12.—A good type of horse cultivator, well suited to garden use.

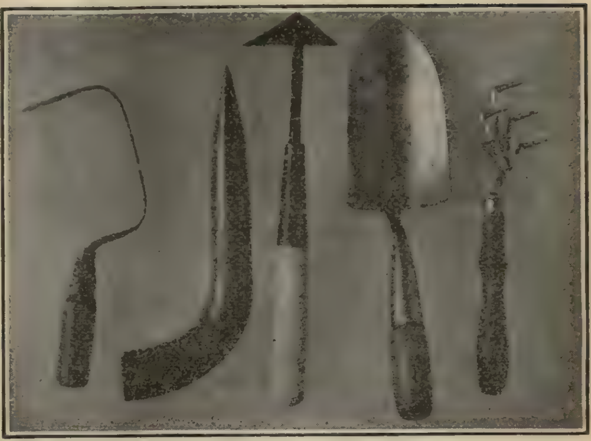

FIG. 13.—Small hand tools for the garden. From left to right they are a hand weeder, a dibble, an onion hoe, a trowel, and a scratch or claw weeder.

kill the weeds between the rows before they become large, but handwork will be necessary to keep the soil stirred between the plants and to keep down weeds in the row. A collection of useful hand tools is shown in figure 13.

In addition to the horse-drawn implements found on most farms, the following tools are desirable aids in the task of laying out and caring for a garden: A tapeline 50 or 100 feet long, two iron stakes, a heavy line long enough to reach the full length of the rows (a clothesline is excellent for this purpose), a wheelbarrow, a spade, a spading fork, a hoe, a garden rake, a trowel, and a 4-prong or 5-prong potato hoe. To the above list may profitably be added a scratch weeder, a pointed hoe, and special tools for which the individual gardener has a preference.

The hand cultivator shown in figure 14 should be included in the equipment of every gardener. This implement is fitted for using a variety of attachments, enabling the gardener to do many kinds of work with it.

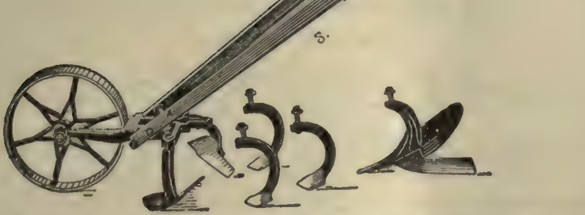

FIG. 14.—A small hand cultivator; a desirable addition to the garden equipment.

IRRIGATION OF GARDEN CROPS.

Throughout that portion of the country where rains occur during the growing season it should not be necessary to irrigate in order to produce the ordinary garden crops. In arid regions where irrigation must be depended upon for the production of crops, the system best adapted for use in that particular locality should be employed in the garden. Wherever irrigation is practiced the water should not be applied until needed, and then the soil should be thoroughly soaked. After irrigation, the land should be cultivated as soon as the surface becomes sufficiently dry, and no more water should be applied until the plants begin to show the need of additional moisture. Constant or excessive watering is very detrimental in every case. Apply the water at any time of the day that is most convenient and when the plants require it.

By the subirrigation method of watering, lines of farm draintiles or perforated pipes are laid on a level a few inches below the surface of the soil. This system is especially adapted for use in back-yard gardens where city water is available and the area under cultivation is small. Subirrigation is expensive to install, as the lines of tiles should be about 3 feet apart, or one line for each standard row. By connecting the tiles at one end by means of tiles across the rows, the water may be discharged into the tiles at one point from a hose and will find its way to all parts of the system, entering the soil through the openings.

For further information on irrigation, see Farmers' Bulletin 864, entitled "Practical Information for Beginners in Irrigation," or Department of Agriculture Bulletin 495, entitled "Spray Irrigation."

FALL AND WINTER CARE OF THE GARDEN.

In the autumn, after the crops have been removed, it is a wise plan to remove all vines, dead plants, and other trash and sow the ground to rye or some other green crop. This will prevent the earth from washing, and the green material will improve the physical condition of the soil. If this can not be done, it is well to plow or spade the garden and allow the ground to lie rough through the winter. This practice permits the frost to kill insects as well as to lighten the soil by alternate freezing and thawing. Many gardeners make a practice of plowing the ground and applying coarse manure, which decays and mixes with the soil during the winter. Well-rotted manure is best, applied to the rough freshly plowed ground so the leachings will be retained.

INSECTS AND DISEASES AFFECTING GARDEN CROPS.

In the control of insects and diseases that infest garden crops it is often possible to accomplish a great amount of good by careful management. In the autumn, after the crops have been harvested or as fast as any crop is disposed of, any refuse that remains, if it is diseased or infested with insects, should be gathered and burned. Several of the garden insects find protection during the winter under boards and any loose material that may remain in the garden. Dead vines or the leaves of plants are frequently covered with the spores of diseases that affect those crops during the growing season, and these should be burned, as they possess very little fertilizing value.

This subject is treated in Farmers' Bulletin 856, entitled "Control of Diseases and Insect Enemies of the Home Vegetable Garden," to which reference is made for detailed suggestions for the control of insects and diseases affecting vegetables.

THE STORAGE OF SURPLUS VEGETABLES FROM THE GARDEN.

It is as important to properly store the surplus vegetables as to grow them. The successful storage of vegetables is not at all difficult; in fact, good storage facilities already exist in most homes, it being only necessary to make use of the cellar, the attic, a large closet, or some other part of the dwelling, depending upon the character of the product to be stored. A cool well-ventilated cellar under the dwelling offers good conditions for the storage of such vegetables as potatoes, carrots, beets, and other root crops. If such a cellar is not available it is often possible to store in banks or pits or in outdoor cellars. For information on the storage of vegetables, see Farmers' Bulletin 879, entitled "Home Storage of Vegetables."

CULTURAL HINTS FOR THE VARIOUS GARDEN CROPS.

ARTICHOKE, GLOBE.

Deep, rich sandy loam, with a liberal supply of well-rotted manure, is best suited for growing artichokes. Plant the seeds as soon as the soil is warm in the spring, and when the plants have formed three or four leaves they may be transplanted to rows 3 feet apart and 2 feet apart in the row. The plants do not produce until the second season, and in cold localities some form of covering will be necessary during the winter. This crop is not suited for cultivation north of the line of zero temperature.

After the bed is once established, the plants may be reset each year by using the side shoots from the base of the old plants. If not reset the bed will continue to produce for several years, but the burs will not be so large as from new plants. The bur, or flower bud, is the part used, and the burs should be gathered before the blossom part appears. If they are removed and no seed is allowed to form, the plants will continue to produce until the end of the season.

ARTICHOKE, JERUSALEM.

The Jerusalem artichoke will grow in any good garden soil, and should be planted 3 to 4 feet apart each way, with three or four small tubers in a hill. If large tubers are used for planting, they should be cut like Irish potatoes. Plant as soon as the ground becomes warm in the spring and cultivate as for corn. A pint of tubers cut to eyes will plant about 30 hills. The tubers will be ready for use in October, but may remain in the ground and be dug at any time during the winter.

The tubers are prepared by boiling until soft, and are served with butter or creamed. They are also used for salads and pickles.

The Jerusalem artichoke is not of great importance as a garden vegetable, and the plant has a tendency to become a weed.

ASPARAGUS.

Asparagus should have a place in every home vegetable garden where it will thrive. This crop can be grown on almost any well-drained soil, but will do best on a deep, mellow sandy loam. There is little possibility of having the land too rich, and liberal applications of partly rotted barnyard manure should be made before the plants are set. The seeds of asparagus may be sown during the early spring in the rows where the plants are to remain and the seedlings thinned to stand 14 inches apart in the row at the end of the first season. It is usually more satisfactory to purchase 2-year-old roots from some seedsman or dealer. The price of good roots is generally about $1.25 per hundred, and 100 to 200 plants will be found sufficient to supply the ordinary family. The roots should be transplanted during the late autumn or early spring.

Before setting out the plants, the land should be loosened very deeply, either by subsoil plowing or deep spading. It is a good plan to remove the topsoil and spade manure into the subsoil to a depth of 14 or 16 inches; then replace the topsoil and add more manure. There are two methods of setting an asparagus bed, depending entirely upon the kind of cultivation to be employed in the garden. If horse tools are to be used, the plants should be set in rows 3½ feet apart and 14 inches apart in the row. On the other hand, if the garden space is limited, the plants should be set in a solid bed, 1 foot apart each way, and cultivated by hand. In setting asparagus, the crowns should be covered to a depth of 4 or 5 inches. It will be desirable to mulch the asparagus bed during the winter with 3 or 4 inches of loose manure or straw.

The part of the asparagus used as a vegetable is the young shoot that is thrown up during the early spring. The shoots are removed when about 4 or 5 inches in length by cutting slightly below the surface of the ground, but care should be taken that the knife is not thrust at an angle, or the crowns will be injured. If so desired, the shoots may be blanched by ridging up over the rows with loose sandy soil or by allowing the mulch to remain and the shoots to make their way through it; but unblanched asparagus always has a better flavor than blanched, is more easily produced, and is more satisfactory for home use. Too heavy mulching has a tendency to retard the growth of the shoots by keeping the ground cold until late in the spring.

No shoots should be removed the first year the plants are set in the permanent bed, and the period of cutting should be short the second year. After the second year the plants become well established, and with proper fertilizing and care the bed will last indefinitely. During the cutting season all the shoots should be removed, as the roots will cease to throw up shoots as soon as one is allowed to mature. When the shoots become tough and stringy or are no longer desired for use, the cutting should cease and the tops should be allowed to grow during the summer. Late in the autumn, when the tops become dead, they can be removed and burned, the soil between the rows cultivated, and a fertilizer or mulch applied. For full information, see Farmers' Bulletin 829, entitled "Asparagus."

BEANS.

Beans will not withstand much cold, so they should not be planted until danger of frost is past and the ground begins to warm up. The first planting should be made as soon as the ground is reasonably warm, and other plantings may be made at intervals of ten days or two weeks until hot weather sets in. Beans for the fall garden should be planted in late summer, and successive plantings may be made at the intervals suggested until about eight weeks before the time for the first frost in the autumn.

Bush beans should be planted to stand 3 or 4 inches apart in rows 30 inches apart where horse cultivation is to be used. For hand cultivation, 20 to 24 inches between the rows will be satisfactory. Among the best varieties of bush beans are the Stringless Green Pod, Refugee, Hodson's Kidney Wax, Currie's Rustproof Wax, and Wardwell's Kidney Wax.

Lima beans, both pole and bush, should be grown in the garden. These should be planted after all danger of frost is over and the soil is warm. Plant the pole beans 8 to 10 seeds in a hill and thin to 3 or 4 after the plants become established. The hills should be 4 or 5 feet apart. Pole Lima beans may also be planted along the garden fence, allowing the vines to utilize the fence as a support. For bush Lima beans, plant 5 or 6 inches apart in rows 30 to 36 inches apart.

When planting beans of any kind the seed should not be covered over 2 inches, and on heavy soils they should not be covered more than 1¼ to 1½ inches.

Seibert's Pole Lima, Carpinteria Lima, and King of the Limas are good varieties of pole Lima beans, and Landreth's Bush Lima, Dreer's Bush Lima, and Henderson's Bush Lima are good varieties of the bush type.

For further information on bean growing, read Farmers' Bulletin 289, entitled "Beans."

BEETS.

Beets can be planted as soon as danger of frost has passed, even before the ground has become warm. Sow the seeds in drills 14 to 18 inches apart, covering to the depth of about 1 inch. As soon as the plants are well up, thin them to stand 3 to 4 inches apart. Make two or three plantings, so as to have a continuous supply of young, tender beets throughout the season. In many sections of the South, beets may be left in the ground through the winter, to be pulled when wanted.

Varieties recommended: Crosby's Egyptian, Bassano, Early Eclipse, and Early Blood Turnip.

BORECOLE. SEE KALE.

BRUSSELS SPROUTS.

Brussels sprouts are closely related to cabbage and cauliflower, and may be grown in the same manner. Instead of a single head, Brussels sprouts form a large number of small heads in the axils of the leaves. As the heads begin to crowd, the leaves should be broken from the stem of the plant, to give them more room. (See fig. 15.) A few leaves should be left at the top of the stem, where the new heads are being formed. Brussels sprouts are more hardy than cabbage, and in mild climates may remain in the open ground all winter, the heads being removed as desired. For winter use in cold localities, take up plants that are well laden with heads and set them close together in a pit, coldframe, or cellar, with a little soil around the roots.

The uses of Brussels sprouts are similar to those of cabbage, but they are considered to be of a superior flavor.

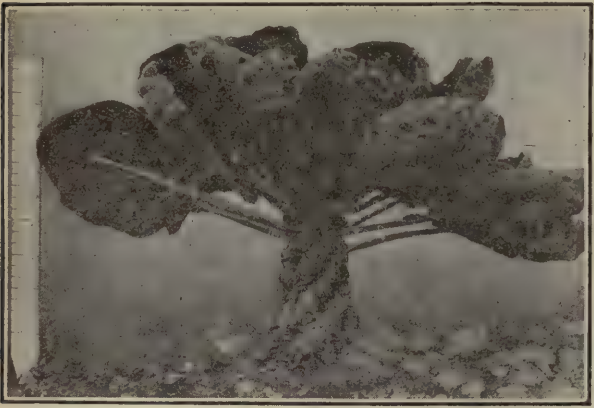

FIG. 15.—A single plant of Brussels sprouts. The miniature heads are cut off and cooked like cabbage.

BUR ARTICHOKE. SEE ARTICHOKE, GLOBE.

CABBAGE.

In some sections of zones D and E it is possible to set early cabbage plants in the

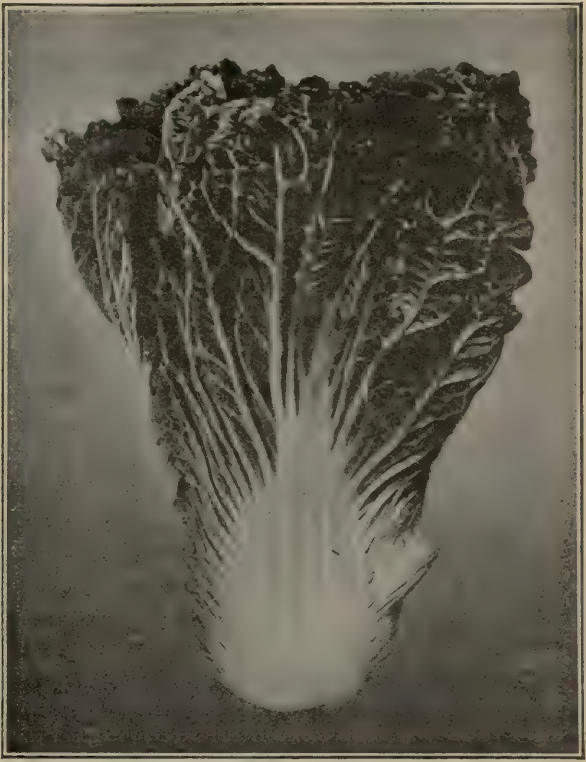

FIG. 16.—A trimmed head of Chinese cabbage ready for use.

autumn. When this is done, the ground should be ridged and some protective covering given the plants during the winter. When set in the spring, the seed should be started in a hotbed or greenhouse in February and in the open ground as soon as the soil can be worked. For a late crop in the North, plant the seeds in a bed in the open ground in May or June and transplant to the garden in July. Early cabbages require a rich, warm soil in order that they may mature early. For late cabbages, the soil should be heavier and more retentive of moisture and not so rich as for the early crop, as the heads are liable to burst. Cabbages should be set in rows 30 to 36 inches apart and 14 to 18 inches apart in the row. Early cabbages must be used soon after they have formed solid heads, as they will not keep during hot weather. They can, however, be used for making sauerkraut. For details as to the method of making and keeping summer kraut, see Farmers' Bulletin 881, entitled "Preservation of Vegetables by Fermentation and Salting." Late cabbage may be kept in storage cellars, banks or pits, or in trenches surrounded with poles, banked with dirt and covered over the top with straw. For detailed directions for the storage of cabbage, see Farmers' Bulletin No. 879, entitled "Home Storage of Vegetables."

CABBAGE, CHINESE.

Chinese cabbage is said by botanists to be very closely related to the turnip. It makes a head of erect leaves, which is stemless and rests on the ground. (Fig. 16.) It is often listed by seedsmen as Pai T'sai, or Petsay, which is a form of its Chinese name (Pe-tsai).

The plant may be used as a potherb, like kale or spinach, or when headed it is a fine salad plant, being more tender when cut up than ordinary cabbage.

It is difficult to get the Chinese cabbage to head in the spring, especially in the South, so that it is usable only as greens from the spring crop. For the fall crop it should be planted at the same time as fall turnips, as it matures in much less time than ordinary cabbage.

The plant demands very rich well-drained soil, but must not be allowed to suffer from lack of moisture. Seed should be started in a seed bed and the plants transplanted when they are quite small. They should be set not closer than 2 feet apart each way and will repay careful and continuous cultivation.

CANTALOUPE. SEE MELONS, MUSKMELON.

CARDOON.

The cardoon is a thistlelike plant, very similar in appearance to the Globe artichoke, but is grown as an annual. The seeds are sown in early spring in a hotbed or coldframe and the plants transplanted later to the open ground. The cardoon should be planted in rows 3 feet apart and 18 inches apart in the row on rich soil, where it can secure plenty of moisture and make rapid growth. Toward autumn the leaves are drawn together and the center blanched in the same manner as the endive. If intended for winter use, the leaves are not blanched in the garden, but the plants are lifted with considerable earth adhering to the roots and stored closely in a dark pit or cellar to blanch. The blanched leaf stems are used for making salads, soups, and stews.

CARROT.

The culture of the carrot is practically the same as the parsnip, except that carrots are not thinned so much and are allowed to grow almost as thickly as planted. Carrots should be dug in the autumn and stored, like parsnips or turnips. Any surplus can be fed sparingly to horses, mules, or cattle.

CAULIFLOWER.

Cauliflower requires a rich, moist soil, and thrives best under irrigation. It will not withstand as much frost as cabbage. The culture is the same as for cabbage until the heads begin to develop, after which the leaves may be tied together over the heads in order to exclude the light and keep the heads white. This point is brought out in figure 17.

CELERIAC.

Celeriac is a large-rooted form of celery used for cooking only. Cultivate the same as celery, but banking or blanching is not required. The roots may remain in the ground until wanted for use provided a light covering is applied to prevent freezing.

CELERY.

For the North, sow the seed in a hotbed or coldframe and transplant to the open ground. Celery plants are generally improved by transplanting twice. Celery seeds are very small and are slow in germinating. and the temperature of the seed bed should be kept low. The seed bed should be especially well prepared, and the seeds should not be covered to a greater depth than one-eighth of an inch. Watering should be attended to very carefully, and the bed should not dry out. After the plants are up, care should be taken that the bed does not become too wet and the plants damp-off. Five hundred plants will be sufficient for the ordinary family. They should be set 6 inches apart in rows 3 to 5 feet apart.

Celery requires a deep, rich, moist soil, with plenty of well-rotted barnyard manure or fertilizer and frequent shallow cultivations. In the garden, celery may be planted after some early crop, such as lettuce, radishes, peas, or beans. As soon as the plants attain con-

FIG. 17.—Cauliflower with the leaves tied up so that the heads will remain white.

siderable size, the leaves should be drawn up and a little soil compacted about their bases to hold them upright. If the blanching is done with earth, care should be taken that the hearts of the plants do not become filled. Boards, paper, draintiles, or anything that will exclude the light may be used for blanching, but earthing up will produce the finest flavor.

Celery may be kept for winter use by banking with earth and covering the tops with leaves or straw to keep it from freezing, or it may be dug and removed to a cellar, coldframe, vacant hotbed, or pit, and reset close together, with the roots bedded in earth. While in storage, celery should be kept as cool as possible without freezing.

The blanched stems of celery are eaten in the raw state, and both the stems and enlarged roots are stewed and creamed. Celery seed is used for flavoring soups and pickles.

CHERVIL.

Under the name of chervil two distinct plants, known as salad chervil and the turnip-rooted chervil, are cultivated. The seeds of the salad chervil are sown in spring, and the crop will thrive on any good garden soil. The seeds of the turnip-rooted chervil should be sown in the early autumn, but they will not germinate until the following spring.

The edible part of this plant is the root, which somewhat resembles the carrot and is used in the same manner. The leaves are used the same as parsely for garnishing and in flavoring soups.

CHARD.

Chard, or Swiss chard, is a beet which is grown for its foliage instead of its root. The leaves are cooked and used, in very much the same way as spinach, as a potherb or greens. The thickened leaf stem is sometimes cooked and used in very much the same way as asparagus. One of the good points about this vegetable is that crop after crop of leaves may be cut without injuring the plant.

Chard is planted about the same time and in the same manner as beets, but as the top grows larger it should be given more space than the garden beet. Figure 18 shows a typical plant of Swiss chard.

CHICORY.

Chicory is grown for two or three purposes. The root of this plant is the common adulterant of coffee, and large quantities are used for this purpose. The commercial growing of chicory is confined to a few sections, as the crop will not thrive on every kind of soil.

A deep, rich loam, without an excessive amount of clay or sand, is desirable, and soil that is not too rich in nitrogenous matter is best suited to the production of roots.

The roots of chicory are frequently placed in soil under a greenhouse bench or in a warm cellar and covered with a foot or more of straw or with a light covering of straw and then several inches of warm manure. Under this covering the leaves will be formed in a solid head, which is known on the market as witloof.

Chicory has run wild in some parts of the country and is considered a bad weed. The blue flowers of the chicory, which are borne the second season, are very attractive.

As a potherb, chicory is used like spinach, but the leaves should be boiled in two waters in order to remove the bitter taste. As a salad the roots are dug in the autumn and planted in cellars or under a greenhouse bench, where they produce an abundance of blanched leaves, which are eaten raw. The blanched leaves are also boiled and used as greens.

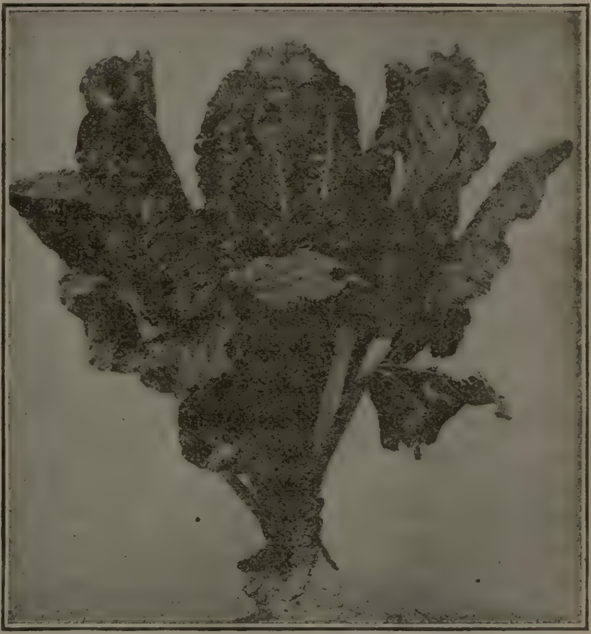

FIG. 18.—Swiss chard, a beet which has been bred for salad foliage instead of its root. The leaves and stalks may be cut repeatedly and used like spinach. Since the plant furnishes salad greens throughout the season, it may well be grown instead of spinach, which furnishes but one crop, or after spinach.

CHIVE.

Chive is a small onionlike plant having flat, hollow leaves which are used for flavoring soups. The chive rarely forms seeds, and it is propagated by the bulbs, which grow in clusters. The leaves may be cut freely and are soon replaced by others.

CIBOL. SEE ONION.

CITRON.

The citron is a type of watermelon with solid flesh which is used for preserves and sweet pickles. The rind of the watermelon is frequently substituted for citron. The cultivation of the citron is the same as for the watermelon.

CIVE. SEE CHIVE.

COLLARDS.

The culture and uses of collards are the same as for cabbage and kale. Collards withstand the heat better than either cabbage or kale and a type known as Georgia collards is highly esteemed in the Southern States. Collards do not form a true head, but instead a loose rosette of leaves, which, when blanched, are very tender and of delicate flavor.

CORN SALAD.

Corn salad is also known as lamb's-lettuce and fetticus. Sow the seed during the early spring in drills 14 to 18 inches apart and cultivate the same as for lettuce or mustard. For an extra-early crop, the seed may be planted during the autumn and the plants covered lightly during the winter. In the Southern States the covering will not be necessary and the plants will be ready for use during February and March. The leaves are frequently used in their natural green state, but they may be blanched by covering the rows with anything that will exclude the light.

Corn salad is used as a salad in place of lettuce or mixed with lettuce or water cress. The flavor of corn salad is very mild, and it is improved by mixing with some other salad plant for use. It is also boiled with mustard for greens.

CORN, SWEET.

Sweet corn should be planted on rich land and cultivated the same as field corn. Plant the seed as soon as the soil is warm in the spring, and makes successive plantings every two or three weeks until late summer. The same results can be obtained to some extent by planting early, medium, and late varieties. Plant the seeds about 2 inches deep in drills 3 feet apart and thin to a single stalk every 10 to 14 inches.

Sweet corn passes so quickly from the milk to the dough stage that care should be exercised to gather the crop just at the right time, in order to secure the most satisfactory results. The flavor of sweet corn depends upon its stage of maturity and the method of handling the product from the plant to the table. Sweet corn loses its sugar content very rapidly after being removed from the stalk. It should, therefore, be picked only a few hours, and preferably a few minutes, in advance of the time when it is to be placed in the pot.

Varieties recommended: For early corn, Golden Bantam and Adams Early are suggested, and for medium and late varieties Black

Mexican or White Mexican, Country Gentleman, and Stowell's Evergreen. The last named variety has the largest ears and is the most productive.

CRESS.

Under the name of cress there are two forms, the water cress and the upland cress. The upland cress, sometimes called peppergrass, is easily grown from seed sown in drills a foot apart. As the plants last but a short time, it will be necessary to make a sowing every few days if a continuous supply is desired.

Water cress can be grown all the year in small open ditches containing running spring water. It is best and most easily produced in water from rather warm springs in limestone regions. A sufficient supply for family use can be grown in a small spring-fed brook, and the plants may be started either from small pieces of plants or from seed. Cress is used in salads, to which it imparts a pleasant pungency.

CUCUMBERS.

The soil for cucumbers should be rich, and it is a good plan to apply well-rotted manure under the rows or hills. If planted in rows, open the furrow and scatter the manure along the furrow, turning fresh soil over the manure before planting the seeds. If the seeds are planted in hills, confine the application of manure to the area occupied by the hills.

As cucumbers are easily injured by cold, it is not advisable to plant until all danger of frost is over and the ground has begun to warm up. For very early cucumbers the seeds should be planted in a hotbed in old strawberry boxes, plant bands, inverted sods, or directly in the soil of the bed. By starting the plants in hotbeds the cucumbers will be ready for the table two or three weeks earlier than if started in the open. For the main crop, drill the seed in rows 5 feet apart and after the plants reach a height of 3 or 4 inches thin them to stand 12 to 18 inches apart in the row, or plant the seeds in hills 4 feet apart each way and thin to 3 or 4 plants to the hill.

Cucumbers should be given frequent shallow cultivation until the vines fill most of the space between the rows; after this, very little attention will be needed, except to pull out weeds by hand. Do not allow any fruit to ripen on the vines until the end of the picking season, as new fruits will not form while the older ones are ripening.

Young cucumber plants are often destroyed by the cucumber beetle. It is possible to protect the plants by covering them with small wooden frames over which mosquito netting has been stretched, or a square of mosquito netting dropped over a peg set in the middle of the hill, the edges of the netting being covered with earth to prevent the netting from blowing off, may be used. Air-slaked lime sprinkled over the small plants is an added protection against the cucumber beetle.

The varieties recommended are White Spine, Davis Perfect, and Emerald.

For further information on cucumber growing, read Farmers' Bulletin 254, entitled "Cucumbers."

DANDELION.

Sow the seed of dandelion in spring in drills 18 inches apart, covering it one-half inch deep. Thin the plants to about 12 inches apart and give good clean cultivation throughout the summer. In the colder parts of the country it may be desirable to mulch slightly during the winter, to prevent the plants heaving out of the soil. Early the following spring the plants will be ready for use as greens, but they are greatly improved if blanched by setting two boards in the form of an inverted letter V over the row. The blanching not only makes the leaves more tender but destroys a part of the bitter taste. Dandelion greens should be boiled in two waters, to remove the bitterness.

EGGPLANT.

The plants for this crop should be started in a hotbed or in a box in the house about two months before time for planting in the field. The plants should not be set in the field until after all danger of frost

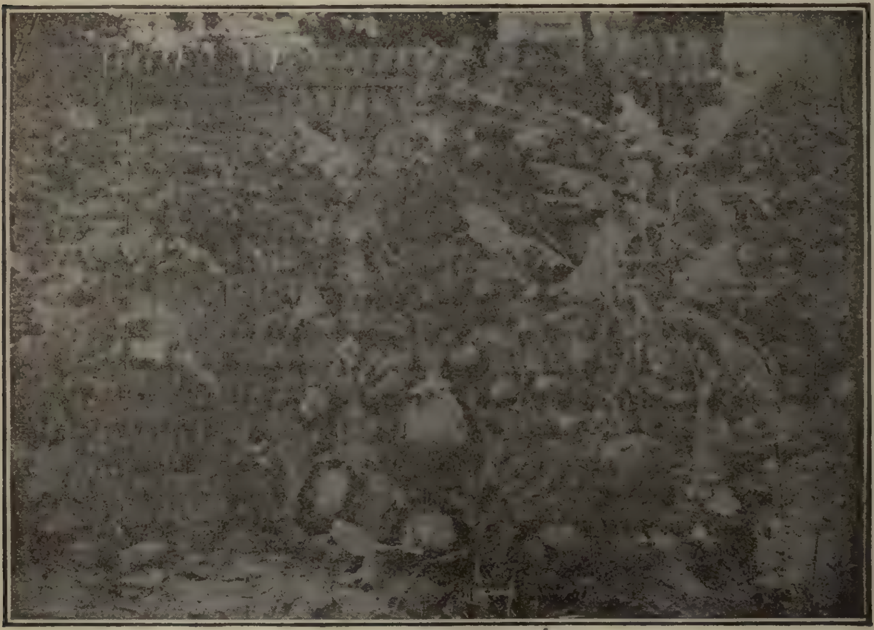

FIG. 19.—The eggplant when grown under good cultural conditions is a prolific yielder. All the fruits shown in the illustration are on a single plant.

has passed and the ground has become quite warm. Set the plants 18 to 24 inches apart in rows 3 feet apart and give clean, shallow cultivation in order to keep the plants growing rapidly. A dozen good, healthy plants will supply enough fruit for the average-sized family throughout the season. (Fig. 19.)

Eggplant may be used in several ways, one of which is the following: Peel and cut into slices one-fourth to one-half inch thick and soak in salt water for an hour; boil until tender; then coat with cracker crumbs or flour and fry in butter or fat. Another method is to steam or bake the eggplant whole, the pulp being eaten from the shell with salt, pepper, and butter.

Varieties recommended: New York Improved Purple, Black Beauty, and Florida High Bush.

ENDIVE.

The endive is a relative of chicory. Sow the seeds thinly in drills and when the plants are well established thin to 8 inches. Water and cultivate thoroughly in order that a good growth of leaves may be made. When the leaves are 6 to 8 inches in length, draw them together and tie them so the heart will blanch. The leaves should not be tied up while wet, or decay will follow. The heads should be used as soon as blanched. For winter use, sow the seeds rather late and remove the plants, with a ball of earth adhering to the roots, to a cellar or coldframe, and blanch during the winter as required for use.

Endive is used as a salad at times of the year when lettuce and similar crops are out of season.

FETTICUS. SEE CORN SALAD.

FLAG. SEE LEEK.

FRENCH ARTICHOKE. SEE ARTICHOKE, GLOBE.

GARLIC.

Garlic is closely allied to the onion, but will remain in the ground from one year to another if undisturbed. Garlic is planted by setting the small bulbs, or cloves, either in the autumn or early spring. The culture is practically the same as for the onion. The bulbs are used for flavoring purposes.

GERMAN CELERY. SEE CELERIAC.

GROUND-CHERRY. SEE PHYSALIS.

GUMBO. SEE OKRA.

HORSE-RADISH.

Horse-radish will thrive best in a deep, rich soil where there is plenty of moisture. The rows should be at least 3 feet apart and the plants 12 to 18 inches apart in the row. Tops cut from large roots or pieces of small roots are used for planting. A comparatively few hills of horse-radish will be sufficient for family use, and the roots required for starting can be secured of seedsmen for 25 or 30 cents a dozen. This crop will require no particular cultivation except to keep down the weeds, and is inclined to become a weed itself if not controlled.

The large fleshy roots are prepared for use by peeling and grating. The grated root is treated with a little salt and vinegar and served as a relish with meats, oysters, etc. The roots should be dug during the winter or early spring before the leaves start. After being treated with salt and vinegar the grated root may be bottled for summer use.

HUSK-TOMATO. SEE PHYSALIS.

IRISH POTATO. SEE POTATO, IRISH.

JERUSALEM ARTICHOKE. SEE ARTICHOKE, JERUSALEM.

KALE, OR BORECOLE.

There are a large number of forms of kale, and these are thought by some to be the original type of the cabbage. Kale does not form a head, and has convoluted leaves and thick leaf stems. It may be set in rows and cultivated the same as cabbage or may be sown broadcast but set somewhat closer. This crop is very hardy and will live through the winter in the open ground in localities where freezing is not too severe. The flavor of kale is improved by frost.

Kale is used for greens during the winter and as a substitute for cabbage.

KOHL-RABI.

Kohl-rabi belongs to the same class as cabbage and cauliflower, but presents a marked variation from either. The edible portion consists of the swollen stem of the plant, as shown in figure 20. For an early crop, plant and cultivate the same as for early cabbage. For a late crop or for all seasons in the South, the seed may be sown in drills where the crop is to be grown and thinned to about 8 inches apart in the row. The rows should be from

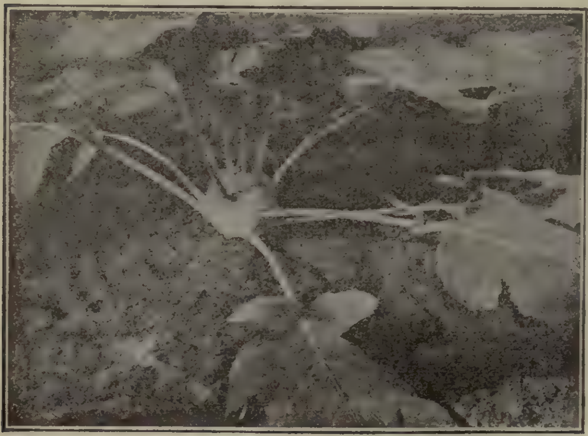

FIG. 20.—Kohl-rabi, showing the swollen stem, which grows above ground.

18 to 36 inches apart, according to the kind of cultivation employed. The fleshy stems should be used while they are young and quite tender.

LAMB'S-LETTUCE. SEE CORN SALAD.

LEEK.

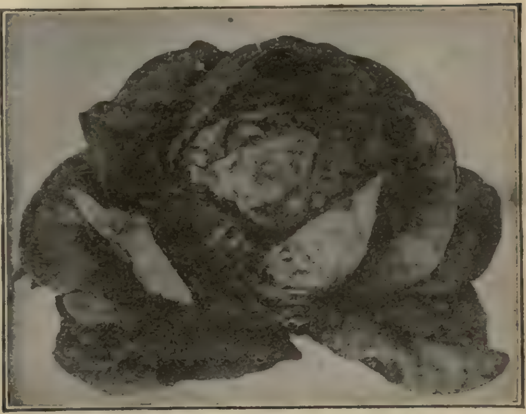

FIG. 21.—Head lettuce produces very tender, almost white leaves in the center of the heads, but is somewhat harder to grow than the loose-leaf sorts.

This plant belongs to the same class as the onion, but requires somewhat different treatment. Leeks can be grown on any good garden soil and are usually sown in a shallow trench. The plants should be thinned to stand about 4 inches apart in the row and the cultivation should be similar to that for onions. After the plants have attained almost full size, the earth is drawn around them to the height of 6 or 8 inches in order to blanch the fleshy stem. The leek does not form a true bulb like the onion, but the stem is uniformly thick throughout. Leeks are marketed in bunches, like young onions, and they may be stored the same as celery for winter.

Leeks are used for flavoring purposes and are boiled and served with a cream dressing, the same as young onions.

LETTUCE.

Lettuce attains its best development in a rich sandy loam in which there is plenty of organic matter. It thrives best during the early spring or late autumn and will not withstand the heat of summer. In order that the leaves may be crisp and tender, it is necessary to force the growth. The usual method of growing lettuce for home use is to sow the seeds broadcast in a bed and remove the leaves from the plants as rapidly as they become large enough for use. A much better method is either to thin or transplant the seedlings and allow the plants to form rather compact heads and then cut the entire plant for use.

The seeds may be sown in a hotbed or coldframe and the seedlings transplanted to the open ground, or the seeding may be in rows in the garden and the plants thinned to 5 or 6 inches in the row. Lettuce may be grown in rows about 12 inches apart. In order to produce crisp and tender lettuce (fig. 21) during the summer months, it may be necessary to provide some form of partial shading.

Varieties recommended: Grand Rapids and Black-Seeded Simpson for loose-leaf lettuce, and Big Boston, Hanson, and California Cream Butter for head lettuce.

MELONS.

Muskmelon.—The culture of the muskmelon is the same as for the cucumber except that the plants are usually given more space. Plant 8 to 10 seeds in a hill, spacing the hills 6 feet apart each way. After the plants become established, thin out all but four of the best ones. Another method is to sow in drills 6 feet apart and thin to single plants 18 to 24 inches apart.

Varieties recommended: Rocky Ford, Netted Gem, Emerald Gem, Eden Gem, Jenny Lind, and Paul Rose.

Watermelon.—The cultivation of the watermelon is the same as for the cucumber and muskmelon except that the plants require more space. Plant watermelon seed in rows 8 to 10 feet apart and thin to single plants 3 feet apart, or plant in hills 8 to 10 feet apart each way.

Varieties recommended: Kleckley Sweet, Florida Favorite, Georgia Rattlesnake, and Tom Watson.

MUSKMELON. SEE MELONS, MUSKMELON.

MUSTARD.

Almost any good soil will produce a crop of mustard. The basal leaves of mustard are used for greens, and as the plants require but a short time to reach the proper stage for use, frequent sowings should be made. Sow the seeds thickly in drills as early as possible in the spring, or for late use sow the seeds in September or October. The forms of white mustard, of which the leaves are often curled and frilled, are generally used. Mustard greens are cooked like spinach.

NEW ZEALAND SPINACH. SEE SPINACH, NEW ZEALAND.

OKRA, OR GUMBO.

Sow the seeds of okra in the open after the ground has become quite warm, or start the plants in berry boxes in a hotbed and transplant them to the garden after all danger of frost is past. The rows should be 4 feet apart for the dwarf sorts and 5 feet apart for the tall kinds, with the plants 2 feet apart in the row. Okra does best in rather rich land and requires frequent shallow cultivations until the plants cover the ground.

The young pods are the part used, and these are employed principally in soups, to which they impart a pleasant flavor and mucilaginous consistency. If the pods are removed from the plants and none allowed to ripen, the plants will continue to produce pods until killed by frost, but the best pods are grown on young plants. Okra pods can be dried or canned for winter use.

For further information on okra, see Farmers' Bulletin 232, entitled "Okra: Its Culture and Uses."

ONIONS.

For very early bunch onions it is the common practice to plant sets in drills 12 to 14 inches apart and 2 to 3 inches apart in the row. The sets may be put out as early in the spring as the land can be prepared.

For dry onions, sow the seed thickly in drills about 12 to 14 inches apart in the spring, as soon as danger from hard frosts is over. For early bulbs the seed may be planted in a hotbed or coldframe and the young plants transplanted to the open when conditions are favorable. Plants 4 or 5 inches high are of good size for transplanting.

Onions require frequent shallow cultivations, and it may be necessary to resort to hand weeding. When the tops begin to die and the bulbs are full grown, the onions should be pulled and left in the field for a few days to dry. Then the tops should be clipped off and the bulbs placed in crates or bags and stored in a well-ventilated place to cure.

Early green onions may also be produced from the Multiplier or Potato varieties planted in the autumn. The large bulbs of these onions contain a number of "hearts," or buds, and if planted will produce a number of small onions. The small onions have but one "heart" and will produce large bulbs. A few large bulbs should be planted each year, to produce sets for fall planting.

The Top, or Tree, onion produces a number of bulblets on top of the stem. These small bulbs can be planted in the autumn and will produce onions the following spring.

Varieties recommended: Southport White Globe, Southport Red Globe, Danvers, Red Wethersfield, Australian Brown, and Prize Taker. In some sections of the South the Creole is grown, and the Louisiana, or Red Creole, is a popular variety. The Bermuda is a good type of mild-flavored onion and is desired by many. The important varieties of the Bermuda onion are Crystal Wax, White Bermuda, and Red Bermuda.

For additional information on onion growing, read Farmers' Bulletin 354, entitled "Onion Culture."

OYSTER PLANT. SEE SALSIFY.

PARSLEY.

After soaking the seeds of parsley for a few hours in warm water, they may be sown in the same manner as celery seed and the plants transplanted to the open ground. At the North, parsley will live over winter in a coldframe or pit, and in the South it will thrive in the open ground during the winter; but it can not withstand the heat of summer. The plants should be set in rows 12 inches apart and every 4 inches in the row.

The leaves of parsley are used for garnishing meats and for flavoring soups.

PARSNIP.

Sow the seeds of parsnip as early as convenient in the spring in drills 18 inches to 3 feet apart. Thin the plants to stand 3 inches apart in the rows. The parsnip requires a rich soil and frequent cultivation. The roots can be dug late in the fall and stored in cellars or pits or allowed to remain where grown and dug as required for use. It is considered best to allow the roots to become frozen in the ground, as the freezing improves their flavor. As soon as the roots begin to grow the following spring, they will no longer be fit for use. All roots not used during the winter should be dug and removed from the garden, as they will produce seed the second season and become of a weedy nature. When the parsnip has been allowed to run wild the root is considered to be poisonous.

PEAS.

Garden peas, sometimes called English peas, are not injured by light frosts, so they should be planted as soon as the soil can be put in order in the spring. The first plantings should be of small-growing, quick-maturing varieties, such as the Alaska, First and Best, and

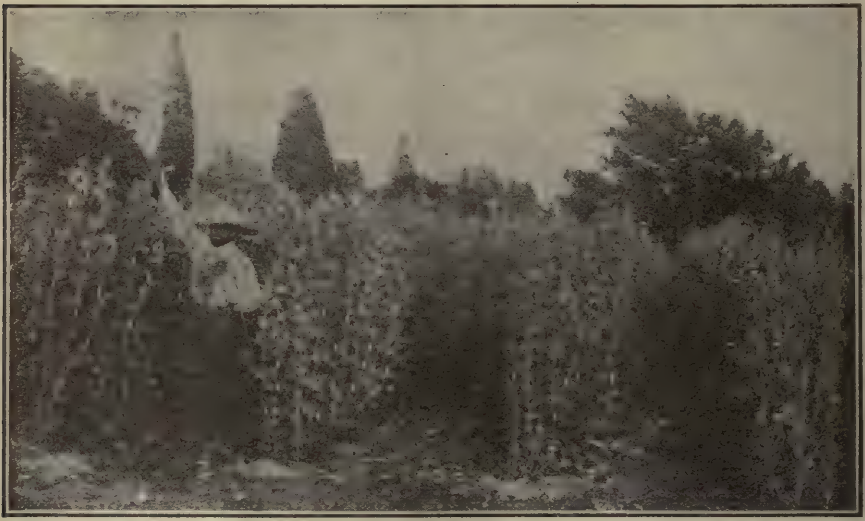

FIG. 22.—Tall-growing peas of the Telephone type, supported on brush.

Gradus, which do not require supports. These varieties should be followed by the large wrinkled type of peas, such as the Champion of England, Telephone, and Prize Taker. The large-growing varieties should be supported on brush, as shown in figure 22, on strings attached to stakes driven in the ground, or on wire netting. In order to have a continuous supply of peas, plantings should be made every ten days or two weeks until warm weather. Peas should be planted in late summer and autumn for the fall garden, for which the early varieties are more desirable than the late ones.

Peas should be planted about 10 seeds to the foot, 2 to 3 inches deep, in rows 3 to 4 feet apart. Some gardeners, however, follow the practice of planting in double rows 6 inches apart, with the ordinary space of 3 to 4 feet between these pairs of rows. This is a good practice with varieties requiring support, as the supports can be placed in the narrow space between the rows.

PEPPERS.

Seeds of peppers should be sown in a hotbed or in a box in the house about eight weeks before the time for settling the plants in the garden. The plants are tender and should not be transplanted until the ground is warm and all danger of frost is past. Set the plants 15 to 18 inches apart in rows 2½ to 3 feet apart. The cultivation and treatment of peppers should be the same as for tomatoes and eggplants. There are a large number of varieties of peppers, including the sweet kinds and the hot peppers.

Varieties recommended: Ruby King, Chinese Giant, Sweet Spanish, and Bell or Bull Nose, of the sweet peppers; Long Red Cayenne, Tabasco, and Red Cluster, of the hot types.

PEPPERGRASS. SEE CRESS.

PHYSALIS.

The physalis is also known as the ground-cherry or husk-tomato. Sow the seed in a hotbed or coldframe and transplant to the garden after danger of frost is past, or the seeds may be sown in the row where the plants are to remain and thinned to 12 or 18 inches. No particular care is required except to keep them free from weeds. There are a large number of varieties of physalis, and the fruits vary in size and color. The variety commonly used in gardens produces a bright-yellow fruit, which is about the size of an ordinary cherry. Toward fall the fruits will drop to the ground and will be protected for some time by their husks. If gathered and placed in a cool place the fruits will keep for a long time. The physalis will self-sow and may become a weed, but it is easily controlled. A few of the volunteer plants may be lifted in the spring and placed in rows instead of making a special sowing of seed. Ten plants will produce all the husk-tomatoes desired by the average family. The fruits are excellent for making preserves and marmalade.

PIEPLANT. SEE RHUBARB.

POTATO, IRISH.

A rich, sandy loam is best suited to the production of Irish potatoes and the fertilizers employed should contain a high percentage of potash. The main crop of Irish potatoes for family use should be grown elsewhere, but a small area of early ones properly belongs in the home garden. The preparation of the soil should be the same as for general garden crops.

Early potatoes should be planted as soon in the spring as it is feasible to work the land, irrespective of locality. Late potatoes are extensively grown in the North, and the planting should be done late in May or during June. The rows should be not less than 2 feet apart and the hills 12 to 15 inches apart in the row. Lay off the rows with a 1-horse plow or lister and drop the seed, one or two pieces in a place, in the bottom of the furrow. Cover the seed to a depth of about 4 inches, using a hoe or a 1-horse plow for the purpose. One to three weeks will be required for the potatoes to come up, depending entirely upon the temperature of the soil. The ground may freeze slightly after the planting has been done, but so long as the frost does not reach the seed potatoes no harm will result, and growth will begin as soon as the soil becomes sufficiently warm.

As soon as the potatoes appear above ground and the rows can be followed, the surface soil should be well stirred by means of one of the harrow-toothed cultivators. Good cultivation should be maintained throughout the growing season, with occasional hand hoeing, if necessary, to keep the ground free from weeds. Toward the last the soil may be well worked up around the plants in order to hold them erect and protect the tubers from the sun after the vines begin to die.

After digging the potatoes, they should not be allowed to lie exposed to the sun or to any light while in storage, as they soon become green and unfit for table use. Early potatoes especially should not be stored in a damp place during the heated part of the summer and will keep best if covered with straw in a cool, shady shed until the autumn weather sets in, after which they can be placed in a dry cellar or buried in the open ground. The ideal temperature for keeping Irish potatoes is between 30° and 40° F., but they will not withstand any freezing.

POTATO, SWEET.

The sweet potato is of a tropical nature and succeeds best in the warm sandy loam soils of the Southern States. Sweet potatoes are, however, grown commercially as far north as the southern line of the State of Pennsylvania, and for family use even in southern New York and Michigan. A warm, loose sandy soil is best adapted to the production of sweet potatoes, and good drainage is essential. In order to improve the drainage conditions, it is customary to set the plants on top of ridges, which are thrown up by means of a plow, two furrows being turned together. For best results the soil should be well fertilized throughout, but in commercial sweet-potato culture the plan is frequently adopted of placing the fertilizer or manure in a furrow and then turning the ridge up over it. The manure should be evenly distributed, and it is advisable to run a cultivator once or twice in the furrow to mix the manure with the soil. Too much manure in one spot under the hill will produce a large growth of vine at the expense of the potatoes.

Toward the northern part of the area over which sweet potatoes are grown, it is necessary to start the plants in a hotbed in order that the length of season may be sufficient to mature the crop. The roots that are too small for marketing are used for seed, and these are bedded close together in the hotbed and covered with about 2 inches of sand or fine soil, such as leaf mold. The seed should be bedded about five or six weeks before it will be safe to set the plants in the open ground. Toward the last the hotbed should be ventilated very freely, in order to harden off the plants.

The ridges for planting sweet potatoes should be 3 to 5 feet apart and the plants about 14 inches apart in the row. Cultivate sufficiently to keep the surface soil loose and free from weeds, and the vines will soon cover the ground, after which no cultivation will be necessary.

Sweet potatoes are dug as soon as the vines are nipped by frost. They should be dug on a bright, drying day when the soil is not too wet. On a small scale they may be dug with a spading fork, and great care should be taken that the roots do not become bruised or injured in the process of handling. It is desirable that the roots should lie exposed for two or three hours in order to dry thoroughly, after which they may be placed in a warm, well-ventilated room to cure for several days. The proper temperature for curing sweet potatoes is from 80° to 90° F., and 50° to 55° F. afterwards. A small crop may be cured around the kitchen stove and later stored in a dry room where there will be no danger of their becoming too cold. Sweet potatoes should be handled as little as possible. especially after they have been cured.

Varieties recommended: Pumpkin Yam, Dooley, Nancy Hall, Triumph, and Southern Queen. Where a dry-fleshed potato is desired, the Improved Jersey, Big-Stem Jersey, and Triumph are recommended.

For further information on sweet potatoes, read Farmers' Bulletins 324 and 548, entitled "Sweet Potatoes" and "Storing and Marketing Sweet Potatoes," respectively.

PUMPKIN.

The true pumpkin is hardly to be considered a garden crop, and as a rule should be planted among the field corn. Plant where the hills of corn are missing and cultivate with the corn.

RADISH.

The radish is quite hardy and may be grown throughout the winter in hotbeds at the North and in coldframes in zone E. For the home garden the seed should be sown in the open ground as soon as the soil is moderately warm. Plant in drills 12 to 18 inches apart, and as soon as the plants are up thin them slightly in order to prevent crowding. Radishes require to be grown on a quick, rich soil, and some of the earlier sorts can be matured in two to three weeks after planting. If the radishes grow slowly they will have a pungent flavor and will not be fit for table use. For a constant supply successive plantings should be made every two weeks, as the roots lose their crispness and delicate flavor if allowed to remain long in the open ground. As a rule, a large percentage of radish seed will grow, and it is often possible by careful sowing to avoid the necessity of thinning, the first radishes being pulled as soon as they are of sufficient size for table use, thus making room for those that will mature later. Radishes will not endure hot weather and are suited only to early-spring and late-autumn planting.

There are a number of varieties of winter radishes, the seed of which may be planted the latter part of summer and the roots pulled and stored for winter use. These roots should remain in the ground as long as possible without frosting and should then be dug and stored the same as turnips. This type of radish will not compare with the earlier summer varieties, which may be easily grown in a hotbed or coldframe during the winter. An ounce of radish seed is sufficient to plant 100 feet of row, and when grown on a large scale 10 to 12 pounds of seed will be required to the acre.

RHUBARB.

The soil for rhubarb should be deep and there is litttle danger of having it too rich. Like asparagus, the seedling plants of rhubarb can be grown and transplanted. Ten to twelve good hills are sufficient to produce all the rhubarb required by the average family, and the plants are most easily established by planting pieces of roots taken from another bed. Good roots may be secured from dealers and seedsmen at about $1.50 a dozen. The old hills may be divided in the early spring or late fall by digging away the earth on one side and cutting the hill in two with a sharp spade, the part removed being used to establish a new hill.

The usual method of planting rhubarb is to set the plants in hills about 4 feet apart in a single row along the garden fence. If more than one row is planted, the hills should be 3½ or 4 feet each way. The thick leaf stems are the part used, and none should be pulled from the plants the first year after setting. Rhubarb should receive the same treatment during winter as asparagus, and the plants should never be allowed to ripen seed. The roots may be brought into the greenhouse, pit, coldframe, or cellar during the winter and forced. Rhubarb does not thrive in warm climates.

The use of rhubarb is principally during the early spring for making pies and sauces, but the stems may be canned for winter use.

RUTABAGA.

The culture of the rutabaga is the same as for the turnip, except that the former requires more room and a longer season for its growth. The roots are quite hardy and will withstand considerable frost. The rutabaga is used like the turnip and also for stock feed. Two pounds of seed are required for one acre.

SALAD CHERVIL. SEE CHERVIL.

SALSIFY, OR VEGETABLE OYSTER.

Sow seeds of salsify during the spring in the same manner as for parsnips or carrots. An ounce of seed is required to plant 100 feet of row, and on a large scale 10 pounds to the acre. After the plants are well established they should be thinned sufficiently to prevent their crowding. The cultivation should be the same as for parsnips or carrots, and frequent use of a wheel hoe will avoid the necessity for hand weeding. Salsify may be dug in the autumn and stored or allowed to remain in the ground during the winter, as its treatment is the same as for parsnips. Salsify is a biennial, and if the roots are not dug before the second season they will throw up stems and produce seed. It is of a weedy nature and care should be taken that it does not run wild by seeding freely.

Salsify is deserving of more general cultivation, as it is one of the more desirable of the root crops for the garden. Its uses are similar to those of the parsnip, and when boiled and afterwards coated with rolled crackers and fried in butter it has a decided oyster flavor, from which the name "vegetable oyster" is derived.

The Sandwich Island is the variety commonly grown.

SPINACH.

Spinach is one of the best crops grown for greens and should be found in every home garden. In the North it may be planted in early spring, or it can be planted in the autumn and carried over winter by mulching with straw or leaves. Sow the seeds of spinach in drills 1 foot apart at the rate of 1 ounce to 100 feet of row or 10 to 12 pounds to the acre. To produce good spinach, a rich loam which will give the plants a quick growth is required. As ordinarily grown, spinach occupies the land during the autumn and winter only and does not interfere with summer cultivation.

Spinach is an easily grown garden crop, and there is, perhaps, no other of its kind that will give as good satisfaction. Three or four ounces of seed planted in the autumn after a summer crop has been harvested from the land will produce an abundance of greens for the average family during the late autumn and early spring. In gathering spinach, the entire plant is removed and not the leaves. The larger plants are selected first, and the smaller or later ones are thus given room to develop. No thinning is required if this plan of harvesting is practiced.

The Savoy is the variety most commonly grown.

SPINACH, NEW ZEALAND.

The plant known as New Zealand spinach is not a true spinach but grows much larger and should be planted in rows 3 feet apart, with the plants 12 to 18 inches apart in the row. Some difficulty may be experienced in getting the seeds to germinate, and they should be soaked one or two hours in hot water before planting. New Zealand spinach is satisfactory for growing in warm climates, as it withstands heat better than the ordinary spinach. The fleshy leaves and tender stems are cooked the same as spinach.

SQUASH.

There are two types of squashes, the bush varieties and the running varieties. The bush varieties should be planted in hills 4 feet apart each way and the running varieties 8 to 10 feet apart each way. Squashes are prolific, and a supply for the average family will ordinarily be furnished by five or six hills of each sort. Squash seed should not be planted until danger of frost is over and the soil is quite warm. The cultivation and care of squashes should be the same as for cucumbers or muskmelons.

The summer squash is prepared for the table in several ways. It may be boiled and eaten with butter, pepper, and salt, or it may be parboiled and then fried. It may also be sliced without boiling, soaked in water with a little salt, and then fried in egg and bread crumbs or cracker crumbs, like eggplant. Winter varieties are stewed or steamed, to be served with butter and salt, or are prepared in the same way for pie filling. They may also be baked and served in the shell, or the flesh may be scraped out after baking and served with butter and salt.

The varieties of summer squash commonly grown are the Pattypan, Summer Crookneck, and Vegetable Marrow. Of the winter squashes, the Delicious, Pike's Peak, and Hubbard are among the best.

SWEET CORN. SEE CORN, SWEET.

SWEET POTATO. SEE POTATO, SWEET.

TOMATO.

To insure an early crop of tomatoes the seed of a quick-maturing sort should be started about eight weeks before the time for setting the plants in the field. When only a few plants are needed, the seed may be sown in a shallow box in the house. For the best results in growing tomatoes the young plants should be transplanted as soon as they reach a height of 1½ to 2 inches. Transplant these plants to

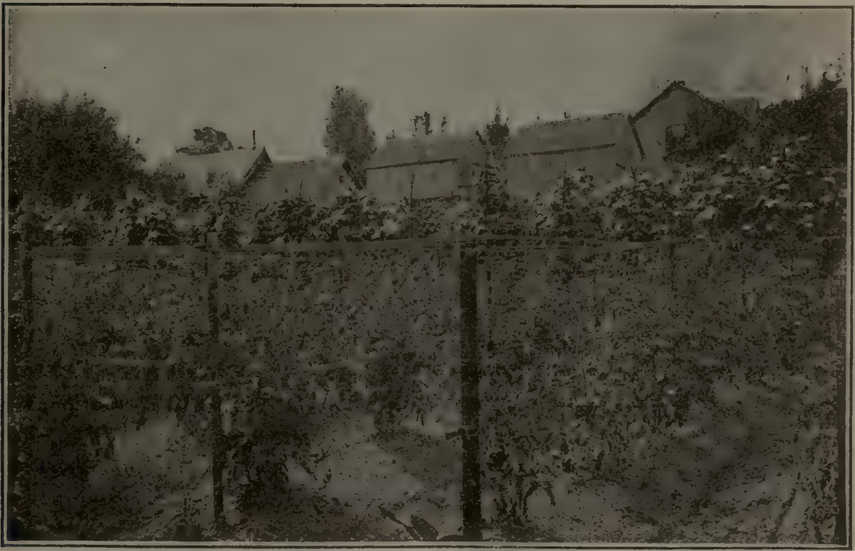

Fig. 23.—Tomatoes supported on a trellis made of stakes, wires, and string. Trained in this manner they may be counted on to make a maximum yield.

stand 2 inches apart each way in a hotbed, coldframe, or box in the house. When the plants begin to crowd, it is a good plan to transplant them to flower pots, plant bands, old strawberry boxes, or tin cans from which the bottoms and tops have been melted.

Tomato plants should be set in the open as soon as danger of frost has passed. If the plants are to be pruned to one or two stems and tied to stakes they should be set 18 inches apart in rows 3 feet apart. If the plants are not pruned or staked they may be planted 3 feet apart in rows 4 feet apart. It is advisable, however, to prune and train to stakes (fig. 23), especially for the early crop, as plants so treated will be healthier and more easily cultivated and will produce fruit which is earlier and more uniform in size and shape than that produced by plants which have not been trained and pruned. Soon after setting the plants in the field a stake should be driven near each plant, to which it may be tied. Care should be exercised to tie the plant so that it will not be injured by the string. A good plan is to loop the string around the stake and tie it under a leaf stem. Go over the patch once every week or 10 days and remove all shoots starting in the axils of the leaves.

Varieties recommended: For early tomatoes, Earliana or Chalk's Early Jewel is recommended, preferably the former. For medium and late varieties the following are suggested: Greater Baltimore, Red Rock, Globe, Beauty, Acme, and Stone. The Stone is usually preferred for canning.

For fuller information on tomato culture, see Farmers' Bulletin 220, entitled "Tomatoes."

TOP ONION. SEE ONIONS.

TREE ONION. SEE ONIONS.

TURNIP.

The turnip requires a rich soil and may be grown either as an early or a late crop. For an early crop sow the seeds in drills 12 to 18 inches apart as early in the spring as the condition of the soil will permit. Two pounds of seed are required to plant an acre. After the plants appear, thin to about 3 inches. The roots will be ready for use before hot weather. For late turnips the seeds are usually sown broadcast on land from which some early crop has been removed. Turnips are quite hardy and the roots need not be gathered until after several frosts. They may be stored in a cellar or buried in a pit outside. Before storing, the tops should be removed.

Turnips are used in pot-boiled preparations with potatoes, cabbage, and meat, are boiled with pork, or mashed like potatoes.

TURNIP-ROOTED CHERVIL. SEE CHERVIL.

VEGETABLE MARROW.

The so-called vegetable marrows are closely allied to the pumpkin, both as to species and habit of growth, the principal difference being that the vegetable marrows are used while quite young and tender and may be baked and served very much the same as sweet potatoes. They should receive thorough cultivation in order that a tender product may be secured and should be gathered while the outside skin is still so tender that it may easily be broken by the finger nail. The flesh is either boiled or mashed or baked in the oven and served with butter while hot.

VEGETABLE OYSTER. SEE SALSIFY.

WATER CRESS. SEE CRESS.

WATERMELON. SEE MELONS, WATERMELON.

WELSH ONION. SEE ONIONS.

WITLOOF. SEE CHICORY.

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superseded by Leaflet 428

APPLE BITTER-ROT AND ITS CONTROL

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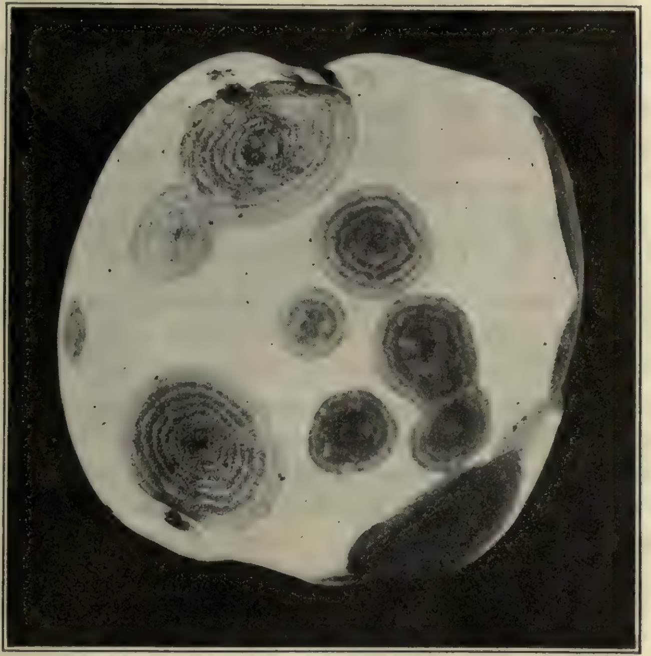

FARMERS' BULLETIN 938

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. April, 1918

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APPLE BITTER-ROT is a serious disease in the southern apple-growing sections of the United States.

Hot weather, particularly if moist, favors the development of the disease, which is disseminated largely by rain and insects.

Different varieties of apples show varying degrees of susceptibility. In new plantings, the more resistant varieties, if otherwise desirable, should be used.

The fungus which causes the disease lives through the winter mainly in mummied fruits and in bitter-rot and other cankers.

Under ordinary conditions and in the average orchard, spraying with Bordeaux mixture will control the disease. Applications of the spray should be made about June 15, July 1, July 15 to 20, and August 1 to 5.

In orchards, especially those of the Middle West, in which the disease has been severe through a term of years or has not proved amenable to spraying, the overwintering sources of infection should be removed.

APPLE BITTER-ROT AND ITS CONTROL.

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DESTRUCTIVENESS OF APPLE BITTER-ROT.

BITTER-ROT OF APPLES (caused by the fungus *Glomerella cingulata*) has long been recognized by orchardists of the southern United States as a disease of great destructiveness, especially in warm, moist seasons, and as one which it is more than ordinarily difficult to control.

In seasons when the rainfall is excessive and the temperature is uniformly high, orchards in which sources of infection are present may lose the entire crop because of bitter-rot. In occasional orchards the sources of infection are so abundant that only a few days of moist, hot weather will bring about the total destruction of the crop. Generally the disease is not very destructive in cool seasons, even though plenty of moisture be present.

The disease may appear from about the middle of June until the early part of September, i. e., at any time during the warmer part of the season. Most commonly, few infected apples are to be found until after the first of July, but the grower should not take the chance of waiting for the appearance of the disease before inaugurating control measures.

Owing to the unevenness of outbreaks of the disease and the part which weather conditions play, it is impossible even to approximate the annual financial loss occasioned by bitter-rot. To the grower, the money loss is increased by the fact that after he has spent time and money in preventing damage by the codling moth, and perhaps by scab or blotch, bitter-rot may appear on previously clean, smooth fruits well on their way to maturity and eventually destroy them.

Typically bitter-rot is a disease of southern apple-growing sections, being of little importance where it is occasionally found in the North.

It is a very serious disease in Maryland, Virginia, West Virginia, southern Indiana, southern Missouri, and to the southward of those States. It reaches its highest point of destructiveness, however, in the more western of the sections mentioned above, being especially serious in Arkansas, southern Missouri, and southern Illinois.

DESCRIPTION.

The first appearance of the disease is indicated by the presence of small light-brown, sometimes almost colorless, spots or blisterlike places just beneath the skin of the apple. Under favorable conditions and where only a few are on an apple these infected areas rapidly increase in size, often attaining a diameter of an inch in four or five days. Beneath these spots are the rotted tissues of the flesh, which extend through to the core, the rotted portion being in the shape of a cone, the base of which is at the surface of the apple and the apex at the core. The rotted flesh often, though not always, has a bitter taste. At first it is watery, in which respect it differs markedly from black-rot (due to *Sphaeropsis malorum*), the only other rot with which bitter-rot is likely to be confused. Later, the rotted portion may increase in size until the entire apple is involved, or it may fail to develop further and become so thoroughly dried that nothing is left but a cone-shaped cavity covered by blackened, dead, papery skin.

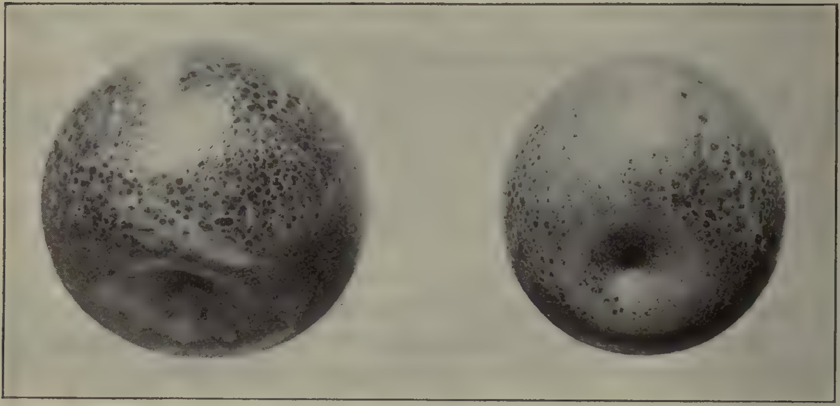

FIG. 1.—Apples with a peppered appearance, due to many infections with bitter-rot. These small blisterlike spots were caused by spores coming directly from a bitter-rot canker on a limb above.

In most cases the tissues about the rotted portion are not discolored by the disease, but yellow apples, especially those of the Yellow Newtown variety, sometimes show a purplish red discoloration of the skin about the affected spot.

When the infections on each apple are many (and there may be as many as a thousand), usually not more than a half dozen of the spots will develop beyond an eighth of an inch in diameter. Often none will develop beyond a sixteenth of an inch in diameter, when the apples will present a peculiar peppered appearance (fig. 1).

After the spots have attained a diameter of about half an inch they become sunken because of the shrinkage of the underlying tissues. About this time, also, the acervuli, or masses of conidia, which are the reproductive bodies of the fungus, begin to appear. These occur in concentric rings and are in the nature of pustules, which upon breaking through the skin appear as rings of small beads, pink at first, later becoming dark brown or black. (See the illustration on the title-page.)

CAUSE OF THE DISEASE.

The fungus[1] which causes apple bitter-rot grows as an interwoven threadlike mass, or mycelium, through the tissues of the apple, between and into the cells, killing the cells themselves and breaking up the tissues. The concentric rings of pink pustules, or acervuli, which later appear on the surface of the rotted spot, are masses of the spores of the fungus, by means of which the disease is transmitted to other fruits. When weather conditions are favorable, a spore which finds lodgment on an apple may germinate and send its germ tube into the flesh, thus starting a rotten spot unless the apple has been covered previously with Bordeaux mixture, in which case the germ tube dies without penetrating the skin of the apple. The fungus also produces a fruiting body, in which spores are produced in small sacs, or asci, within a tiny hard, black, more or less spherical case, or perithecium. This form of fruiting body is often referred to as the ''perfect'' stage of the fungus, but is not of so great importance from a disease standpoint as the pustules (acervuli).

MEANS OF DISSEMINATING BITTER-ROT.

It is through the agency of spores, especially those from the acervuli (imperfect stage), that the disease is transmitted to sound apples. The spore masses, or acervuli, when newly formed are pink and mucilaginous or thinly gelatinous. Later, however, upon drying they become dark colored and of a hard, horny consistency. Their gelatinous nature when wet and their horny consistency when dry prevent their dissemination by wind, but raindrops can spatter them about, especially upon the fruit located below them. Excessive moisture also can cause the spore masses to trickle or drip down from infected fruits and alight upon sound ones. Birds probably play some part in the dissemination of spores, but a much more important rôle is played by insects, more especially flies. It has been demonstrated repeatedly that flies alighting upon infected apples come in contact with the mucilaginous spore masses, some of which adhering to them may be carried to and deposited upon sound fruit.

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[1] *Glomerella cingulata* (Stoneman) Spaulding and Von Schrenk.

RELATIVE SUSCEPTIBILITY OF APPLE VARIETIES.

Most varieties of apples are susceptible to bitter-rot, at least to some extent, but they differ considerably in this respect, as Table I shows. The susceptibility or resistance of a given variety will often vary considerably according to the section of the country in which it is grown and its location with respect to highly susceptible or highly resistant varieties. Weather conditions also constitute an important factor. During prolonged periods of hot, moist weather, the fungus is able to attack successfully varieties which normally are rather resistant.

When new plantings of the apple are made in sections in which bitter-rot is prevalent, preference should be given to the more resistant varieties, provided they are otherwise desirable.

TABLE I.—*Relative susceptibility of apple varieties to bitter-rot.*

- Very susceptible:
  - Corfu.
  - Fallawater.
  - Gibbs.
  - Givens.
  - Highfill.
  - Huntsman.
  - Lansingburg.
  - Smokehouse.
  - Willow.
  - Yellow Newtown.
- Moderately susceptible:
  - Ben Davis.
  - Gano.
  - Grimes.
  - Jonathan.
- Moderately susceptible—Continued.
  - Limbertwig.
  - Missouri.
  - Nero.
  - Northern Spy.
  - Northwestern.
  - Oliver.
  - Paradise.
  - Pilot.
  - Smith.
  - Stark.
  - Winter Queen.
  - York Stripe.
- Rather resistant:
  - Arkansas.
- Rather resistant—Contd.
  - Baldwin.
  - Delicious.
  - Maiden Blush.
  - Rome Beauty.
  - Stayman Winesap.
  - York Imperial.
- Slightly susceptible or resistant:
  - Akin.
  - Arkansas Black.
  - Bismarck.
  - Langford.
  - Ralls.
  - Salome.
  - Winesap.

SOURCES OF INFECTION.

Knowledge as to the places in which the causal fungus is able to live through the dormant season and to develop and reinfect the fruit during the following summer is of importance in determining measures for the control of the disease. If it were possible to eliminate all such places, control would be obtained without further effort.

The fungus causing apple bitter-rot usually lives through the winter in mummied apples, in bitter-rot cankers or cankers in which this fungus is the causal organism, and in cankers caused by other agencies.

Mummied fruits constitute the most common source of infection throughout the bitter-rot section of the United States. A mummied fruit is one which during the previous season has been affected with the disease and has remained on the tree or on the ground in a more or less shriveled condition. In such fruits the fungus is able to exist throughout the winter, producing spores when the hot season returns. The spores from mummies hanging in the tree are spattered by the rain upon the current season's fruits, thus infecting them with the disease (fig. 2). Infection from mummies on the ground takes place through the medium of flies or by actual contact between the mummied fruits and the apples on low-hanging limbs.

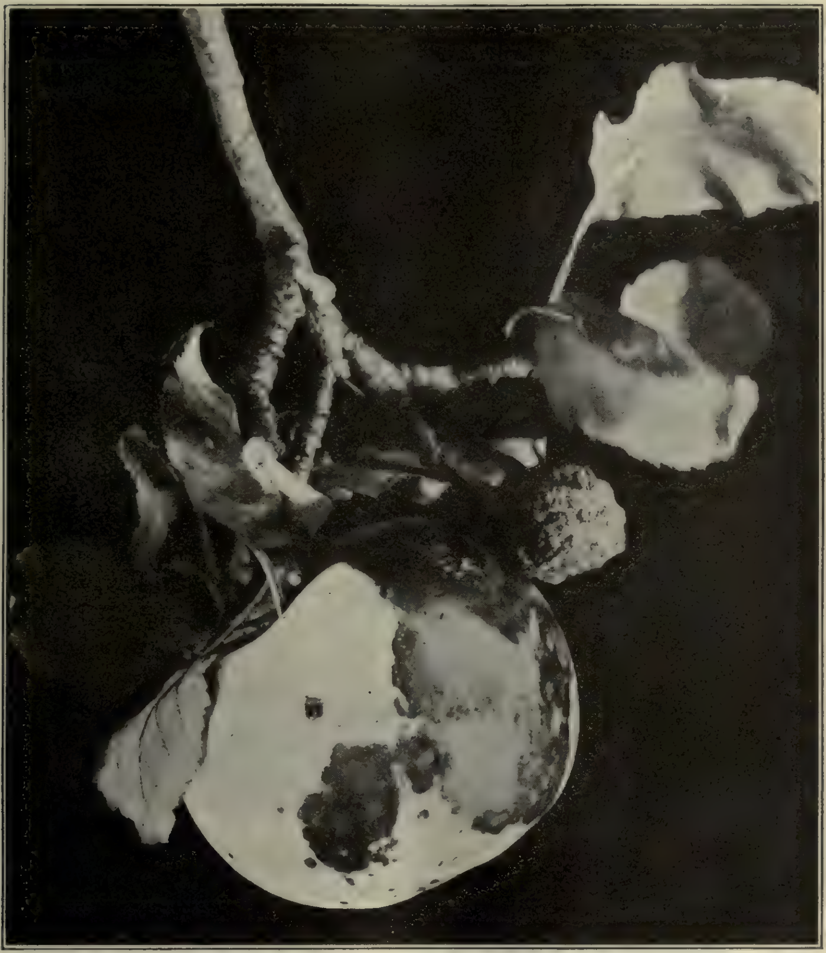

FIG. 2.—An apple affected with bitter-rot and, just above it, a mummied apple of the preceding season. Spores washed down from the mummy have infected the previously sound apple.

The bitter-rot canker is a common source of infection in the western part of the bitter-rot section, but is rare in the eastern part. The canker (fig. 3) consists of a black sunken portion of bark, usually somewhat oval in outline, beneath which the wood is dry and dead. The dead bark and cambium adhere rather firmly to the wood, and in older cankers more or less complete cracks, or fissures, parallel to the edges of the cankers give a zoned effect to the dead bark. Often the canker is surrounded by a layer of callus which prevents its further extension and eventually heals over the old lesion. Cankers usually are not found on branches which are less than two years of age. In cankers the fungus may live one or more years, producing each season immense quantities of spores, which may be carried to sound fruits. The crop of a tree in which there are many bitter-rot cankers during a hot, moist season is doomed to destruction despite frequent and thorough sprayings.

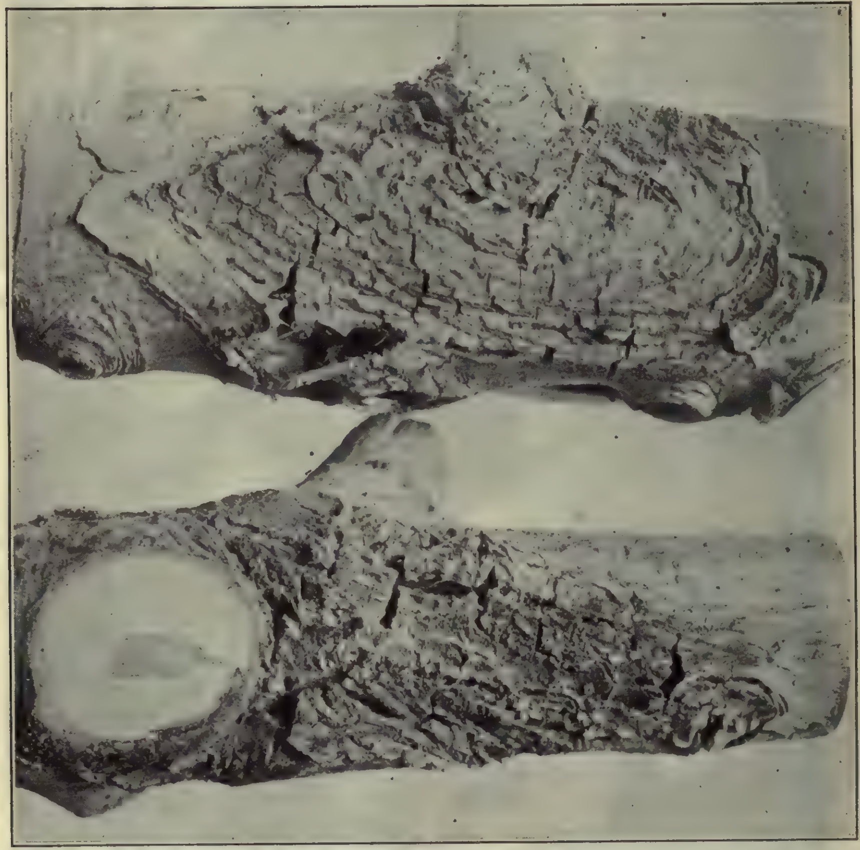

FIG. 3.—Bitter-rot cankers which were located directly above clumps of rotted fruits. These cankers were producing spores in immense numbers.

The susceptibility of different varieties of the apple to this phase of the disease varies to a considerable degree. Among commercial varieties the Givens is very susceptible, while the Jonathan, Missouri, Ben Davis, and Grimes, in the order named, are moderately susceptible. The York Imperial and the Yellow Newtown are practically immune.

The fungus may live through the winter in cankers caused by agencies other than bitter-rot and on dead branches and the tips of fruit spurs. Where the fungus exists in these places and, in addition, mummies and bitter-rot cankers are present, during seasons favorable to bitter-rot any control measures which do not take into consideration the elimination of sources of infection will be inefficient, if not entirely useless.

Infected fruits of the current year also are dangerous sources of infection, since from them sound apples may become infected. It is by them that the disease is spread during the growing season, after it has gained a start from spores produced in the places in which the fungus has passed the winter; therefore, in the control of the disease it is of prime importance to prevent any infections from occurring or, if they do occur, to remove, if practicable, the infected fruits, together with the mummies or cankers from which the infection came, before they can act as infection carriers. The fungus may infect other hosts besides the apple and sometimes occurs on apple leaves, but these are of little importance from the standpoint of disease control.

In the Eastern States mummies are usually the places where the fungus passes the winter, but in the Middle West, especially in badly infected orchards, limb cankers caused by the bitter-rot fungus and by other agencies often surpass mummies in importance.

REMEDIAL MEASURES.

SPRAYING.

Under ordinary conditions and in the average orchard in bitter-rot sections (one in which the disease has not annually destroyed almost the entire crop), three or four thorough sprayings with Bordeaux mixture will afford adequate control. Spraying for the control of bitter-rot, however, must be done with special care, and at least one application should be made before the disease appears.

Bordeaux mixture composed of 4 pounds of bluestone (copper sulphate) and 4 pounds of stone lime to 50 gallons of water should be applied (1) about June 15, (2) two weeks later (about July 1), (3) July 15 to 20, and (4) August 1 to 5.

In cool seasons the intervals between applications may be increased about one week and only three applications made.

For the control of insect pests arsenate of lead at the rate of 2 pounds of paste or 1 pound of powder to every 50 gallons of the Bordeaux mixture may be added in each application, and it certainly should not be omitted from the second one.

In the application of sprays for the control of bitter-rot it should be borne in mind that the object is to cover the fruit completely. In order to do this properly, Vermorel or disk-type nozzles with small openings should be used under a pressure sufficient to give a fine mistlike spray. The best results are obtained by the use of a power sprayer with which a pressure of 200 pounds can be maintained. By manipulation of the spray rods at different angles the spray should be made to strike all parts of the fruit.

Lime-sulphur solution, though efficient in the control of apple scab, will not control bitter-rot.

REMOVAL OF SOURCES OF INFECTION.

In the case of some orchards, especially many of those in the Middle West in which the disease has been very destructive for a term of years, often in spite of frequent and thorough spraying, it will be necessary to remove as many as possible of the overwintering sources of infection, besides following out the spray schedule just mentioned. In some of these orchards the disease has gained such a foothold that at the very first outbreak nearly every apple will show an average of from 50 to 100 points of infection from overwintering sources. Spraying alone under such conditions will act as a preventive to some extent but will not give adequate control. With such abundant sources of infection, control by spraying could be accomplished only by keeping the entire surface of every apple covered with Bordeaux mixture throughout the infection period, which is obviously impossible. In many orchards there will be only a few trees, or perhaps a single section of the orchard, in which the disease is not amenable to control by spraying. Often from such trees the entire orchard will become infected; therefore, special attention should be given to the removal of overwintering sources of infection from them.

The best time for the removal of mummies hanging on the trees is during the dormant season, when they can be poked off with a stick or pulled off by means of a pole with a wire hook attached. If, however, care be taken at picking time to remove the infected as well as the sound fruit there will be few mummies to remove later. Those on the ground can be removed at picking time or at any time before the next summer, or if not numerous they may be turned under when spring cultivation is commenced. In many orchards, such as those planted on rocky hillsides, the removal of mummies on the ground is impracticable; however, they are not nearly so important as those hanging on the trees.

The removal of cankers and dead wood can be carried on to the best advantage in connection with the spring pruning. It is not so difficult an operation as many growers seem to think and is usually not nearly so expensive as a single application of Bordeaux mixture. It should be remembered that the removal of the cankers and dead wood helps to prolong the lives of the trees and is an efficient measure in the control of other diseases, especially black-rot or ring-rot and leaf-spot.

In most cases bitter-rot cankers as well as cankers caused by other agencies will be found on relatively small limbs, and usually they can be removed by simply sawing or cutting off the limbs.

Cankers on large limbs may be removed by means of a sharp knife or, better, a carpenter's gouge. The cut should be made well into the living bark and the margins evenly trimmed unless a callus layer has already begun to form. It is best to sterilize the cut places and tools at every operation with a mercuric-chlorid solution (1 to 1,000 strength). Mercuric chlorid is procurable in tablet form at all drug stores, and directions are given on the bottles for making a 1 to 1,000 solution. After a few days the exposed wood should be coated with a paint composed of white lead and linseed oil, or a mixture of one-third creosote and two-thirds coal tar, using the cheaper grades of these ingredients, may be applied immediately. If the mixture of creosote and coal tar is used it is not necessary to treat the wound with the mercuric-chlorid solution.

The removal of all infected fruit during the growing season is of great importance in preventing the spread of apple bitter-rot, especially when the first application of spray has been made too late or when it appears that the disease is about to gain a foothold early in the season. Of course, this is only practicable at the time the disease first appears and when comparatively few fruits have rotted. At that time it is usually practicable to remove the few infected fruits and to locate and remove many of the overwintering sources of infection overlooked during the dormant season, since the fruits below such sources are the first to be infected. Later, of course, such clumps of infected fruits will not serve as indicators of the location of overwintering sources of bitter-rot, since the infected fruits themselves serve to spread the disease and thus become sources of infection. When the removal of the first infected fruits and corresponding overwintering sources of infection is practiced, a thorough application of Bordeaux mixture should be made directly afterwards. In this way the writers have checked effectually at a nominal cost threatening outbreaks of this disease, in one case the expense of so treating 300 twenty-year-old trees being only $10 in addition to the usual cost of spraying.

All the methods of control herein outlined have been used successfully by the writers and by growers. The sanitation methods recommended are especially adapted to and practicable in the apple-growing sections of northern Arkansas, southern Missouri, and southern Illinois. In three years' time the writers, with the grower's aid, nearly eradicated the disease from one of the worst infested orchards in the United States and had it under control during the very first year.

DIRECTIONS FOR MAKING BORDEAUX MIXTURE.

Bordeaux mixture for use in bitter-rot control should contain ordinarily 4 pounds of bluestone (copper sulphate) and 4 pounds of quicklime to each 50 gallons of water. In orchards in which the disease has not been very serious in previous years, the quantity of bluestone may be reduced to 3 pounds. If the lime used is of poor quality and does not slake readily, 5 or 6 pounds of lime should be used.

To make a single barrel (50 gallons) of Bordeaux mixture, dissolve the bluestone in 25 gallons of water, and in a separate barrel slake the lime and dilute it to 25 gallons. Then pour the contents of the two barrels simultaneously through a strainer into the spray tank.

If large quantities are to be used, a stock solution of the bluestone and a stock milk of lime should be prepared, in order to save time.

A stock solution of bluestone may be made by dissolving it at the rate of 1 pound to each gallon of water. Fill a 50-gallon barrel two-thirds or three-fourths full of water and place a sack (or a box with perforations in the bottom and sides) containing 50 pounds of bluestone in the upper part of the barrel, suspending it by a string or copper wire. In from 12 to 24 hours the bluestone will have entirely dissolved, when the sack or box should be removed and enough water added to fill the barrel. After stirring, the solution is ready for use.

The stock milk of lime may be prepared by slaking 50 pounds of stone lime in a barrel or other vessel and finally adding water to make 50 gallons. In slaking the lime, sufficient water should be used to prevent burning but not enough to "drown" it, and the mass should be continually stirred with a shovel or hoe until a thin paste is formed.

In making Bordeaux mixture, take the necessary quantities of the stock copper-sulphate solution and the stock milk of lime and place them in separate elevated dilution tanks, each of which should hold half as much as the total capacity of the spray tank. Thus, if the spray tank holds 200 gallons, each dilution tank should hold 100 gallons, and, according to the above formula, 16 pounds of copper sulphate (16 gallons of the stock solution) and 20 pounds of lime (20 gallons of stock milk of lime) would be required. To each dilution tank add water (nearly one-half the total amount of spray), and, after stirring, allow the diluted ingredients to run through separate hose or troughs attached to faucets near the bottom of each tank into the strainer on the spray tank, where the two fluids coming together produce the Bordeaux mixture. Only the quantity which can be used during a single day should be prepared, as the mixture deteriorates on standing.

In case dilution tanks are not at hand, a good Bordeaux mixture can be conveniently made without them, provided a power sprayer with a good agitator be used. Simply fill the tank with water until there is room only for the required quantities of the stock fluids. Then starting the engine (and accordingly the agitator), slowly add one stock fluid and then the other. For example, if the tank holds 200 gallons, fill with water to about the 160-gallon mark and then, starting the engine, slowly add the 16 gallons of stock bluestone solution and afterwards the 16 gallons of stock milk of lime; or the milk of lime may be added first. Allow the engine to run for a few minutes after both fluids have been added. Add more water if necessary to fill the tank. By this method an elevated platform is not needed, especially if an efficient mechanical tank filler is at hand.

When arsenicals or other insecticides are to be used with Bordeaux mixture, allowance should be made for these by leaving out the corresponding quantity of water from the quantities specified above.

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CEREAL SMUTS AND THE DISINFECTION OF SEED GRAIN

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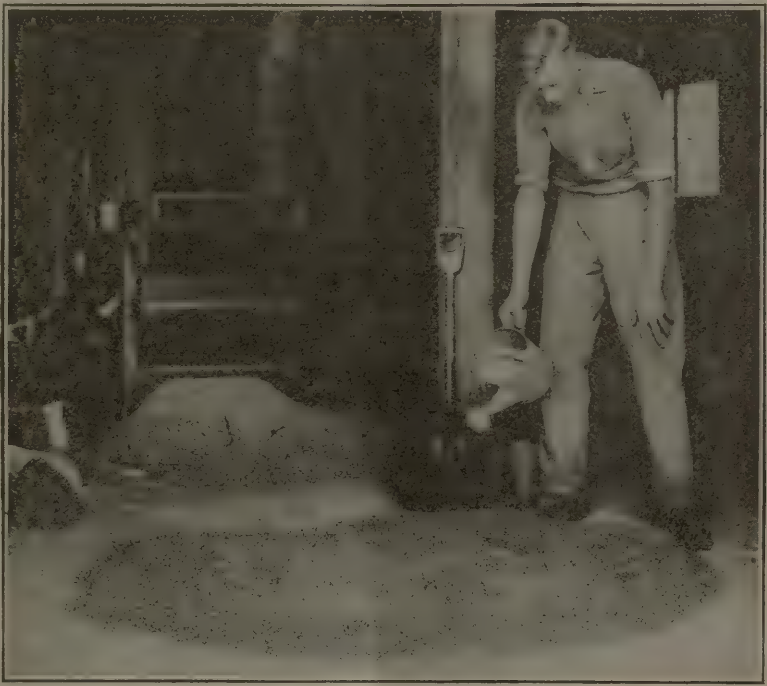

FARMERS' BULLETIN 939

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. April, 1918

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1918

THIS BULLETIN is published for the purpose of providing a condensed but complete source of up-to-date information for practical use in controlling cereal smuts by means of the most generally approved methods for the disinfection of seed grain. It will be of use to the farmer and will serve particularly as a basis for the development of the ever-increasing extension work along this line.

Corn, wheat, rye, barley, oats, sorghum (including kafir and broom corn), and millet smuts are described and illustrated with photographs. There are at least two different kinds of smut which attack each of these cereals and, generally speaking, do not occur on any of the others. Most of them, but not all, are readily prevented.

When using formaldehyde the soaking process should be followed in the case of wheat, barley, and the sorghums. Sprinkling, or sometimes dipping, is more easily done and hence more generally used than soaking, particularly for oats.

Copper sulphate (bluestone) is not recommended for general use, particularly with barley and oats. It has one advantage over formaldehyde, however, in preventing in some degree infection from the soil in case the field has become contaminated. Such soil infection does not occur to any notable extent except in the wheat fields of the Pacific Northwest. Seed grain must be limed after treatment with copper sulphate if injury is to be avoided.

Treatment of seed grain with hot water is chiefly useful in preventing the loose smuts of barley and wheat. These can not be controlled by any other method.

Treating the seed to disinfect it may injure its germination. Such injury can usually be avoided by careful procedure, but it is never safe to sow treated grain without first testing it for germination and increasing the rate of sowing as required. This will result in the best stand of the most vigorous plants obtainable from the seed used.

Disinfecting seed grain will prevent certain diseases other than smuts (but not rusts) and thus may increase the yield even more than would be indicated by simply replacing the smutted with sound grain.

CEREAL SMUTS AND THE DISINFECTION OF SEED GRAIN.

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DESCRIPTION OF THE CEREAL SMUTS.

THE KINDS OF SMUT are as numerous as the kinds of grain, and they differ from each other as essentially as do the different cereals, such as wheat, oats, barley, and rye. These smuts are fungous parasites. They are minute colorless plants of threadlike structure, which, with few exceptions, are able to enter the seedling grain plants just as they start, grow up within the "host" plants thus attacked, and there remain unseen until the heads of grain appear. At this stage the heads of diseased plants are found to be partially or wholly destroyed and replaced by masses of dark-colored fungous spores, the so-called smut. These spores are too small to be seen individually with the naked eye. In each visible smut mass there are thousands, or even millions, of them. They serve to propagate the smut in the next crop by getting on or in the seed, where they are at hand to begin growing again along with the grain when it is planted.

A few of the cereal smuts do not follow this rule of reproduction, and in such cases it is generally more difficult to prevent their attack.

CORN SMUTS.

Of the few smuts for which no specific method of control is known, the common smut of corn (fig. 1) is the most noteworthy. The disinfection of the seed fails to control this parasite, for the reason that it lives over winter in the soil, or sometimes in manure, rather than on the seed. During the growing season the germs of the disease are carried by the wind from the soil where they develop to the growing plants. Falling on the leaves, they are washed down on the young, tender parts in which they can produce the disease later on. Diseased parts are always much swollen and are eventually transformed into the soft masses of smutted tissue which produce the spores of the parasite.

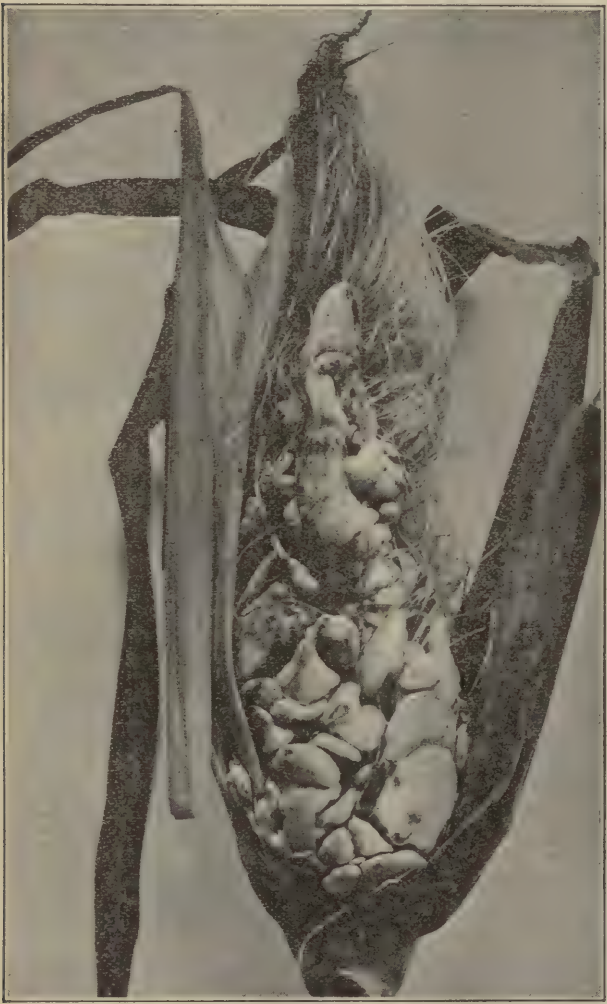

FIG. 1.—Common smut of corn. Smutted ears like the one here shown are common in the fields of the western Plains areas and also on sweet corn. This smut may occur on any part of the plant, though it is generally found in the ear buds on the lower part of the stalk. In Mexico the young smutted parts, which are sweet and tender before they turn black, are used for food.

It has been claimed that spraying the plants is partially successful in eliminating corn smut, but no practicable method has been developed. Where the farming methods are intensive, as with sweet corn, the disease may be partly controlled by cutting and burning all smutted stalks. Rotations are advisable, for continuous cropping to corn undoubtedly increases the losses from smut.

Somewhat like the common corn smut is the head smut (fig. 2). It occurs more frequently on the grain sorghums or on broom corn (p. 14) than on corn, but is not common on either crop. It can not be controlled by disinfection of the seed.

SMUTS OF WHEAT AND RYE.

Three different kinds of smut occur on wheat and rye: Bunt, or stinking smut, loose, or naked, smut, and stem smut. Bunt (fig. 3) is common in wheat, but it is not known to occur on rye in this country. Loose smut (fig. 4) is fairly common, though not often serious in wheat; in rye it is extremely rare. In America stem smut is confined to rye (fig. 5); in Australia it occurs on wheat and is known as flag smut. It will be seen that, as they occur in the United States, these three kinds of smut are practically confined each to one or the other of the two crops and that they are therefore not the same for both of these cereals. It has, indeed, been found to be a general rule that the smuts of one crop do not attack any other crop.

Ordinarily all the smuts of wheat and rye can be prevented by disinfecting the grain before sowing it. Their individual peculiarities, however, require consideration in order that the necessary differences in treatment and the difficulties likely to be encountered may be understood.

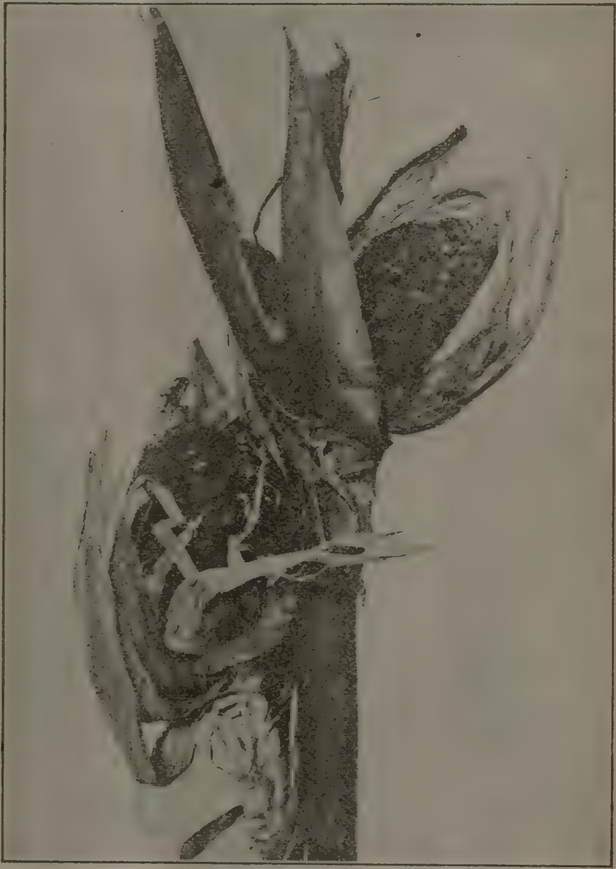

FIG. 2.—Head smut of corn, showing the characteristic destruction of all the ears produced. The tassel is also almost invariably destroyed, but other parts of the plant are seldom attacked. This smut is rare in America. (Illustration from an Australian photograph by D. McAlpine.)

BUNT, OR STINKING SMUT, OF WHEAT.

Two different species of fungi may cause bunt, or stinking smut. One of these, *Tilletia tritici* (fig. 3, on the right), occurs abundantly in the Pacific Northwest, where it causes exceedingly heavy losses. The other, *Tilletia laevis* or *foetens* (fig. 3, on the left), occurs rather commonly in the eastern United States. In Michigan, where both occur, the farmers call the first "low smut" and the second "high smut," because of a difference in the height of the affected plants. While the two kinds have been found to differ also in other particulars, they are generally considered to be so nearly alike that for practical purposes they will here be discussed together.

Before heading, smutted plants of either kind are practically indistinguishable from healthy ones. Even when the heads appear, the disease is not, with most varieties of wheat, at once evident except to the practiced eye. The smutted heads are of a distinctly darker green color than sound ones, and the stalks usually are shorter. From heading time infected fields may sometimes be detected at a considerable distance to the leeward by the disagreeable odor from the smutted kernels, resembling decayed fish. As the crop matures,

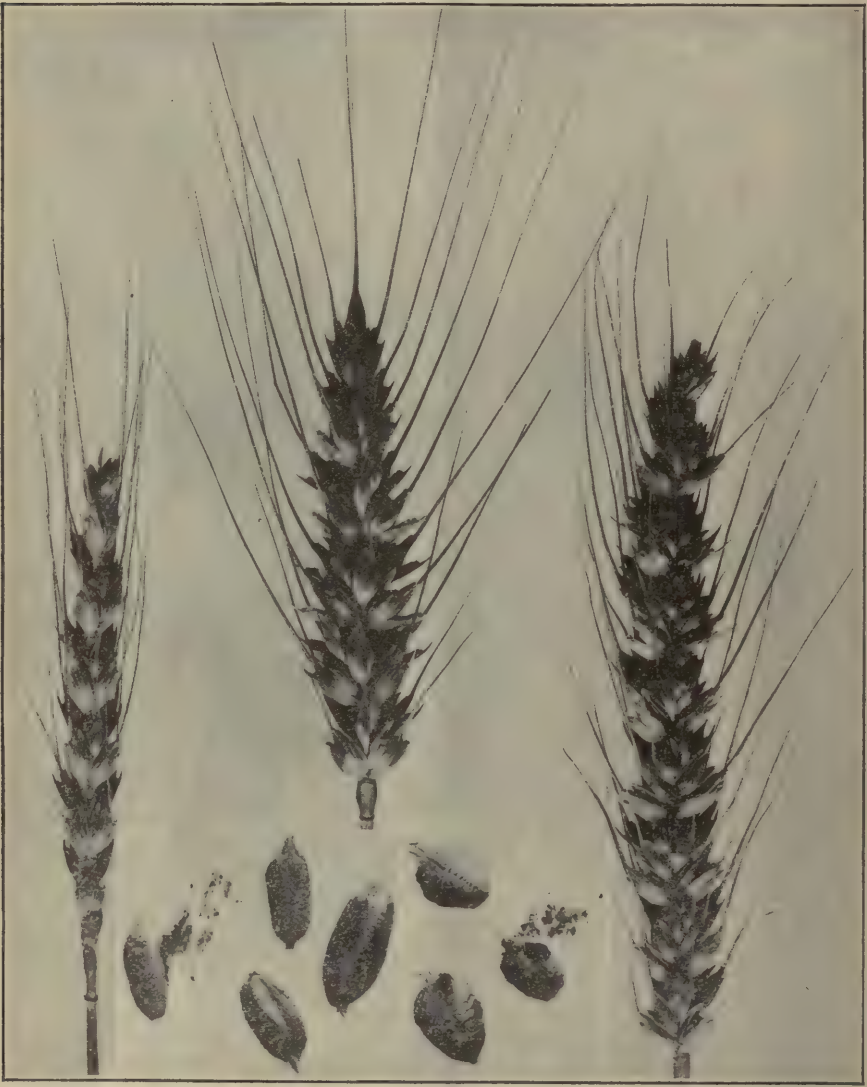

FIG. 3.—Bunt, or stinking smut, showing the two different kinds on Red Rock winter wheat from Michigan, with a sound head in the center for comparison. Smutted kernels, with a sound kernel in the center, are shown below. In the field the stalk bearing the head on the right would be very much shorter than the other two. Not all varieties are affected in just this way, however.

the smutted heads, though standing more erect on account of their lighter weight, usually appear better filled than the sound heads. The chaff is spread widely by the swelling of the enlarged, false kernels, and the beards are frequently deformed and brittle. These false kernels, or smut balls, give the heads a dark color, due to their content of greasy, black spore powder. When thrashed, this smut powder is plentifully distributed on the grain, and if the spores are not killed they will infect the next crop if this grain is used for seed. Since the spores in unbroken smut balls can not be killed readily, the seed must be fanned to remove them or they must be washed out in the process of disinfecting.

The odor and color of the smut seriously affect the thrashed grain for milling purposes, so that it must be scoured clean by special processes. The dockage in price on this account is serious at times, particularly in sections where the mills are not adequately equipped with scourers and washers. The contamination of the grain as regards both quantity and character of smut depends largely on its condition as to maturity and moisture at the time of cutting and thrashing, and is perhaps also dependent upon the variety of wheat and the kind of bunt, though these conditions have not been well determined. If only a few smut balls are left in the grain after thrashing, almost all of these may be removed by careful fanning. On the other hand, if the smut is so smeared over the grain as to make it difficult to clean, or if, as frequently happens in badly smutted crops, a number of partly diseased kernels are present, the market value of the crop will be much lowered. Specific designation of smutty wheat as such, when offered on the market, is required by the regulations recently promulgated under the Grain Standards Act.

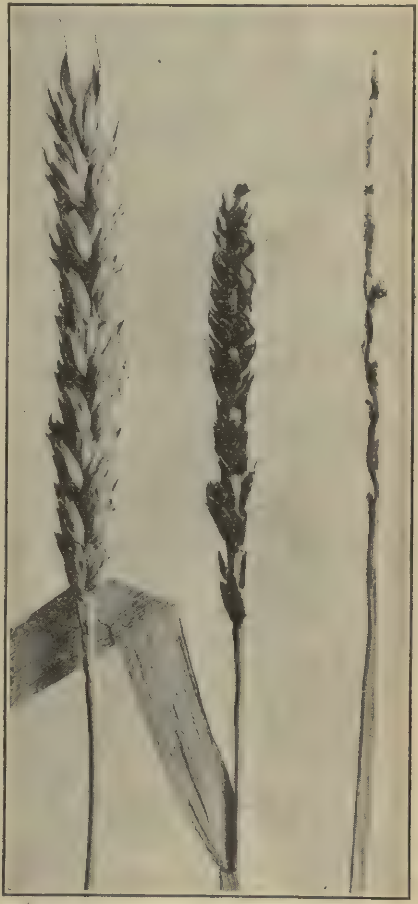

FIG. 4.—Loose smut of wheat (center) showing also a sound head (left) and a naked stem of a smutted head as it appears at harvest time (right). This smut can not be prevented by formaldehyde or other chemical disinfectant.

In some sections where combined harvesters are used, a method for avoiding the serious contamination of the thrashed grain from a smutted crop is sometimes employed by skilled operators who take advantage of the fact that the diseased stalks are shorter than the healthy ones. The sickle bar is so adjusted from time to time that the sound heads are skimmed from the crop, so to speak, thus leaving the smutted ones on the field with the straw. This procedure is especially feasible where the so-called low smut is prevalent, and in connection with continuous cropping to winter wheat it is partly responsible for the difficult situation as to soil infestation which has

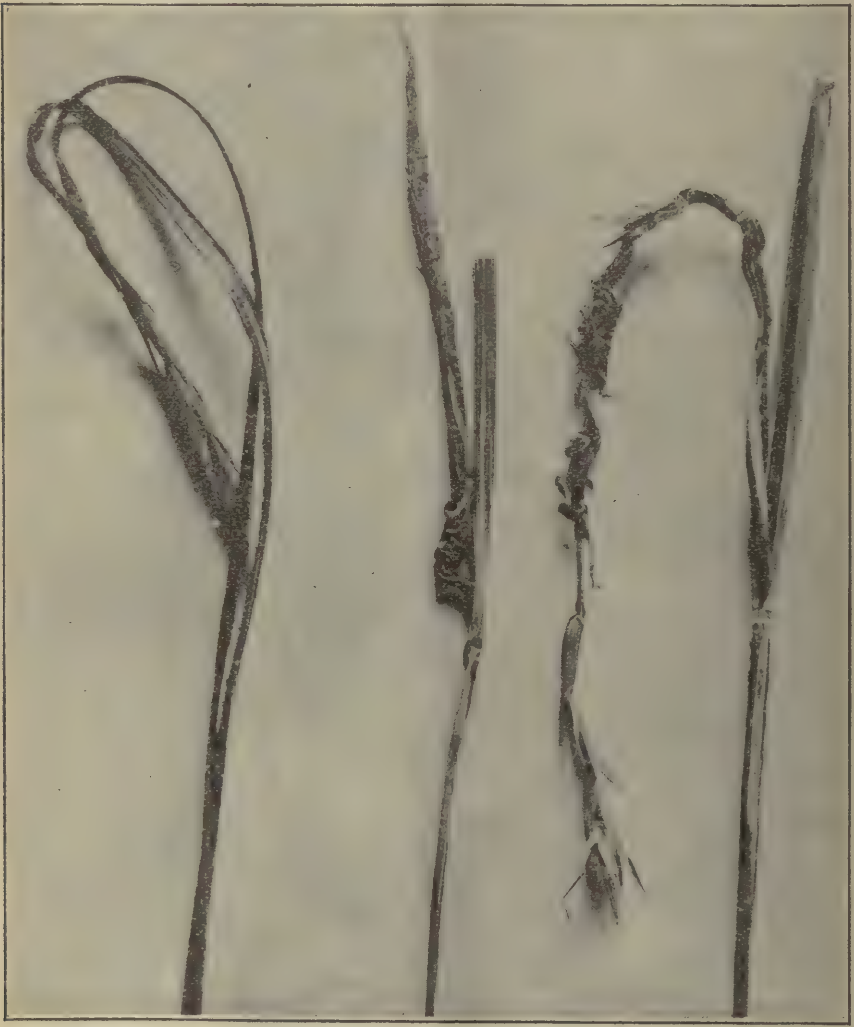

FIG. 5.—Stem smut of rye. Note how the stems are split and twisted and the heads distorted. The losses from this disease until recently have been underestimated. (Specimens collected in Minnesota by Stakman and Levine.)

arisen in the Pacific Northwest. With continuous cropping to wheat, infestation of the soil would also occur to some extent where self-binders are used, for the straw of smutted plants is frequently so brittle that many of the heads are broken off when hit by the reel; also, in the case of the low species of bunt, the straw is generally too short to be bound into the bundles and, though cut, the heads fall out and are left on the field.

In certain areas, particularly that known as the Palouse district of eastern Washington and northwestern Idaho, disinfection of the seed, usually wholly effective elsewhere in preventing bunt, is of comparatively little avail because of the very general infestation of the soil. Even virgin soils in the neighborhood of wheat fields will not grow a clean crop, so general does the infection become from the millions of wind-blown spores set free at harvesting and thrashing time (fig. 6). The influence of this soil infestation is particularly noticeable in the case of winter wheats, especially when sown on land where a thrashing outfit has stood. Also, since the prevailing winds in the Palouse country are from the southwest, the disease is generally worse on north and northeast slopes where the spores from the "smut showers" have settled in larger numbers. Most of the free spores (i. e., those not in unbroken smut balls) are killed during the winter, however, particularly if the seed bed is thoroughly worked over in the autumn. On this account efforts have been made to evade the disease by the thorough cultivation of summer-fallowed fields and by resuming the cultivation of spring wheats, although the latter do not generally yield as well as the winter varieties. Early sowing has also been recommended, since experience has shown that infection is usually much reduced thereby. If the seed is to be sown late, late plowing must also be practiced in order to bury the spores which have fallen on the land during the harvesting and thrashing season. It has been

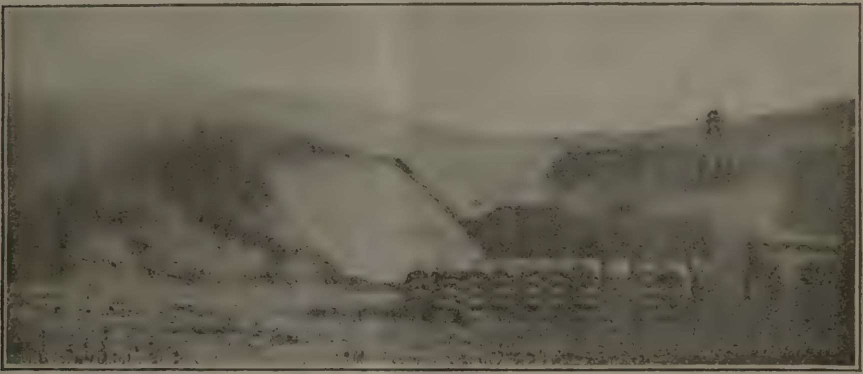

FIG. 6.—Thrashing a smutted crop in the Pacific Northwest. It is not surprising that smut showers, occurring in the vicinity of these operations, make the production of a clean crop of fall-sown wheat a difficult matter.

suggested that some method of soil treatment at seeding might be devised to remedy the situation, but experiments which have been conducted along this line at the Washington State Agricultural Experiment Station have not been encouraging. In addition to these other methods, it is probable that much may yet be accomplished through the development of resistant varieties of wheat. None of these procedures, however, can be more than partially successful so long as an undiversified cropping system is followed. Crop rotation is undoubtedly an essential step in the solution of the bunt problem of the Pacific Northwest.

The losses from bunt in the United States are to be reckoned not only in the reduction in yield, which amounts to about 25,000,000 bushels annually, and in the dockage for smutty grain, probably totaling some $10,000,000 each year, but also in the explosions which sometimes occur during thrashing. The oily nature of the spores makes them extremely combustible when beaten up into a dust. In the State of Washington many thousands of dollars have been lost in a single county in one season as a result of these explosions.

LOOSE SMUT OF WHEAT.

The loose smut of wheat (fig. 4) is distinctly different from most of the other cereal smuts and requires a different method of treatment for its control. Unlike the bunt of wheat, the diseased head bears little resemblance to a sound head. Except for the stem it is totally destroyed, the grain and chaff being replaced by a black, sooty mass. The spores begin to sift out of this mass almost as soon as the head pushes out of the boot and are carried by the wind to neighboring heads, which are in bloom at this time. They lodge between the glumes, or chaff, where, under favoring conditions, they start growth immediately and penetrate the newly forming grains. When these grains ripen they can not be told from sound ones, but they nevertheless contain the germs of the disease. When such an infected seed germinates, the smut plant within starts growth at the same time and develops within the growing grain plant, as already described (p. 3).

The fact that the loose-smut plant has already established itself within the mature seed makes it more difficult to eliminate without injury to the seed than those smuts which are present with the seed only as spores on the outside of the grain. The disease can be prevented, however, by the hot-water treatment, described on pages 23 and 24, provided the grain has been soaked long enough to give the heat a better chance to penetrate and act upon the smut germ.

The loose smut of wheat occurs in practically every field of wheat. The loss from this cause does not commonly exceed 2 per cent of the crop and is usually much less, although fields have been reported where fully one-fourth of the heads were destroyed.

STEM SMUT OF RYE.[1]

The presence of stem smut of rye (fig. 5) generally becomes evident as soon as the stalks begin to shoot up from the stool. As the diseased parts develop, they appear more or less swollen and distorted and of a darker color than the natural green. Later, the swelling becomes somewhat reduced and black spore masses form inside the smutted tissues, usually in long, bluish streaks, which eventually cause the stem to split and twist. The spores are also occasionally formed in the head or leaves. The straw is often so twisted and the stalks so stunted that the smutted plants are scarcely noticeable at harvest. For this reason they are so often overlooked that the rather serious losses which frequently occur in rye-growing sections have until recently been very much underestimated.

The smutted plants are in part harvested and thrashed with the crop and in part left on the ground. In both cases, but particularly in the former, they become a source of disease in the succeeding crop, for, just as in the case of bunt in wheat, the seedling may become infected from spores on the seed or in the soil. Where the disease is to be prevented, therefore, rye should not be grown in successive seasons on the same land, and the seed must be treated in the same manner as wheat for the prevention of bunt.

SMUTS OF BARLEY.

There are two smuts peculiar to barley which from the practical point of view correspond closely to the bunt and loose smut found on wheat in the United States. The head of barley affected with covered smut (fig. 7), however, has no odor, and it is more completely destroyed than a bunted head of wheat, for the chaff of the barley is generally also smutted and the beards are deformed. The diseased heads have a dark, gray color when ripe, are usually borne on shorter stems than the rest of the crop, and appear later than the sound heads. Frequently they scarcely succeed in emerging from the boot. When thrashed, they break up, and the spores are spread through the seed, thus contaminating it for another season. Those broken pieces, or chunks, which can be seen in the thrashed grain, should be removed by fanning before attempting to disinfect the seed.

The loose smut of barley (fig. 8) very closely resembles that of wheat, and the reader may be referred to the description of the latter (p. 10) as giving a practical understanding of both.

The smuts of barley can be found in almost any barley field and frequently cause losses of 5 to 10 per cent. Cases have recently been observed where one-fourth to nearly one-half of the crop in a field was destroyed by the loose smut alone.

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[1] The reader is cautioned not to confuse this disease with the stem *rust*, for which no remedy is known.

SMUTS OF OATS.

The loose and covered smuts of oats (figs. 9 and 10) differ somewhat in external appearance, as their names would indicate. They are also distinguishable from each other by the appearance of the spores under the microscope. The loose smut is quite conspicuous at heading, but is mostly scattered by wind and rain before harvest. On account of the shorter stems, neither kind is very noticeable in a field from a short distance. The smutted heads can usually be located in a green field, however, by the dead upper leaf.

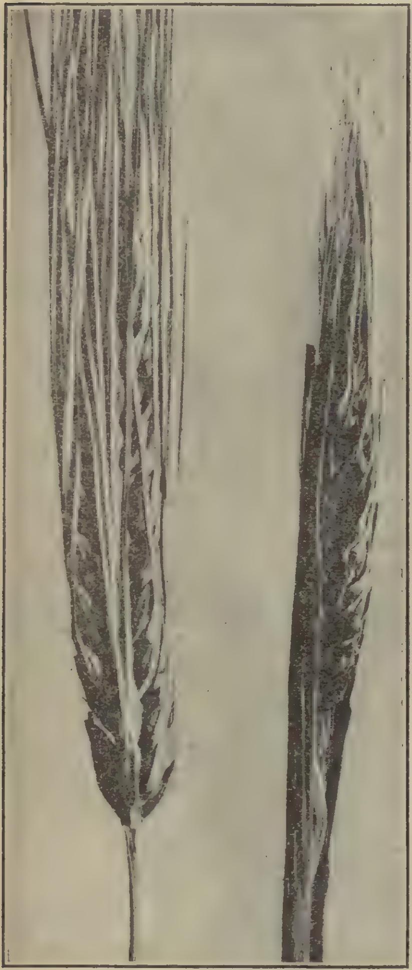

FIG. 7.—Covered smut of barley, showing a smutted head and, for comparison, a sound barley head. When thrashed, the smutted heads break up into chunks, which must be removed from the grain if the disinfection process is to be thorough.

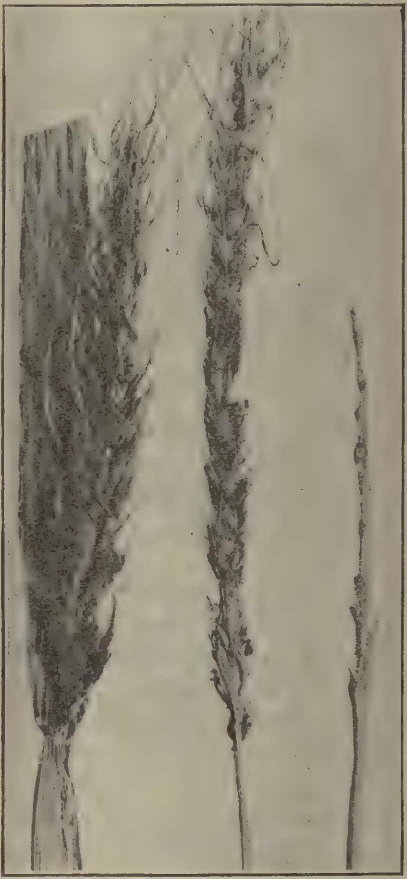

FIG. 8.—Loose smut of barley, showing early and late stages. This smut more closely resembles the loose smut of wheat (fig. 4), both in appearance and in method of attack, than that on oats (fig. 9). In spite of the similarity in appearance these three loose smuts are entirely different, i. e., they will not grow on any other crop than the one on which they were produced.

The differences between the two smuts of oats, though they seem at first to correspond to those which distinguish the two smuts of barley (p. 11), are not known to be of any practical significance.

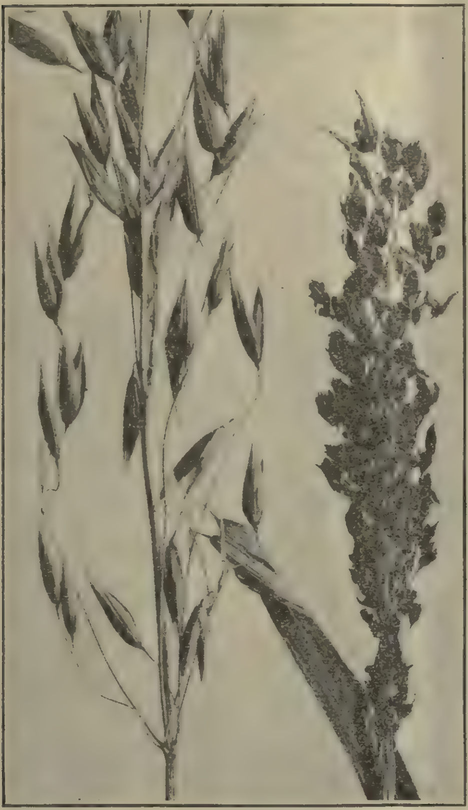

FIG. 9.—Loose smut of oats, showing a smutted head, with a sound oat head for comparison. In spite of the ease with which they may be controlled, this and the covered smut of oats (fig. 10) have been taking a toll from the American oat grower which would feed all the horses attached to 20 army corps of 100,000 men each, or nearly a million head.

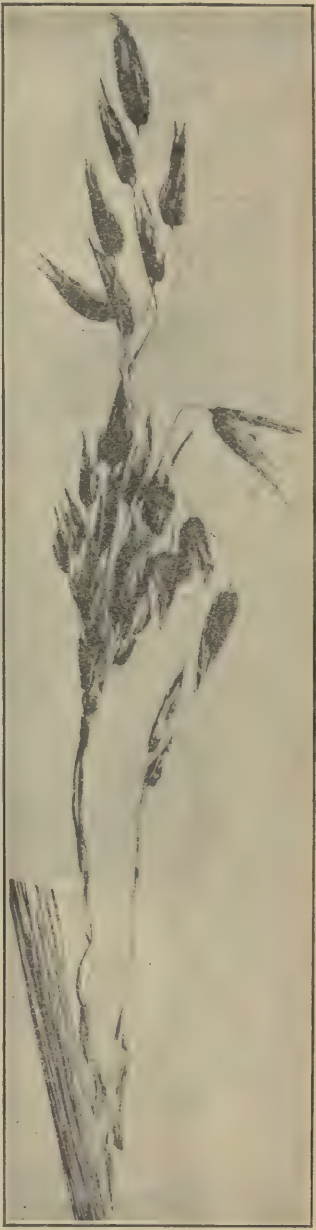

FIG. 10.—Covered smut of oats.

Both of the smuts of oats are preventable by the ordinary methods of seed treatment, since in both cases the spores in the seed oats, which serve to carry the disease over from one crop to another, may be killed without injuring the seed.

In spite of the ease with which losses may be prevented, the smuts of oats have probably been responsible for greater losses, year in and year out, than any other preventable crop disease in the United States. This is because they are inconspicuous at harvest and usually do not in any way injure the quality of the thrashed grain, so that they have been very generally considered unimportant. Indeed, growers frequently insist that they have no smut in their oats when, as a matter of fact, they are losing annually from 5 to 25 per cent or more of their crop. This widespread neglect, coupled with the fact that oats are so largely grown, has made the average yearly loss the country over amount to 50,000,000 bushels or more. The work of the county farm bureaus, established with the aid of funds provided by the Smith-Lever Act, has done much to reduce this loss in the last few years.

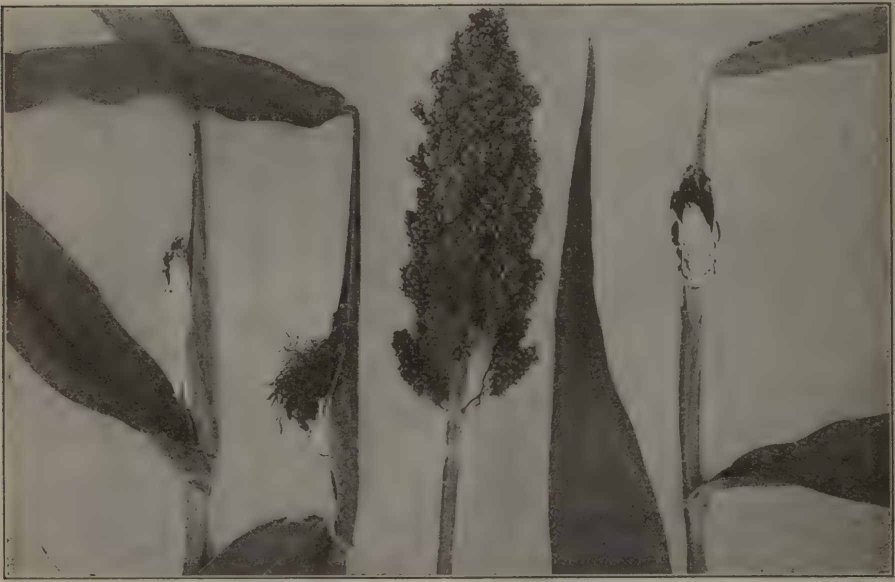

FIG. 11.—Head smut of sorghum on Sumac sorgo, showing three smutted heads, with a sound head of the same variety, for comparison. The young smutted heads are considered a delicacy by certain African tribes.

In the south-central Mississippi Valley the highly resistant character of Burt oats (also called Early Ripe and May oats), which are adapted to that area, has enabled many growers to avoid losses without treating the seed.

SMUTS OF SORGHUM.

The sorghums, including the different kinds of sorgos, or sweet sorghums ("cane"), Sudan grass, kafir, milo, feterita, and broom corn, are subject to a number of smut diseases, of which three are known in this country. The head smut (fig. 11) has already been mentioned (p. 4) as uncommon, and since it can not be prevented by any means other than those suggested for corn smut (p. 4), nothing further need be said about it here.

There are also two kernel smuts (fig. 12), which differ from each other in no essential way. They are like the smuts of oats in that one is loose and the other covered and also in that both usually destroy each kernel separately. As with oats, the treatment of the seed is an effective remedy.

The damage done is frequently serious, particularly in kafir and broom corn. In the latter crop the destruction of the seed would not be of much consequence, but the smut also affects the brush, not only by making it dirty, but also by causing a tendency to coarseness and the formation of a central stem in the head. Kansas authorities estimate a loss of 5 per cent in the kafir crop in average years. Fortunately, milo, feterita, and a few other varieties of grain sorghum have thus far proved to be extremely resistant, and smut seldom occurs in them.

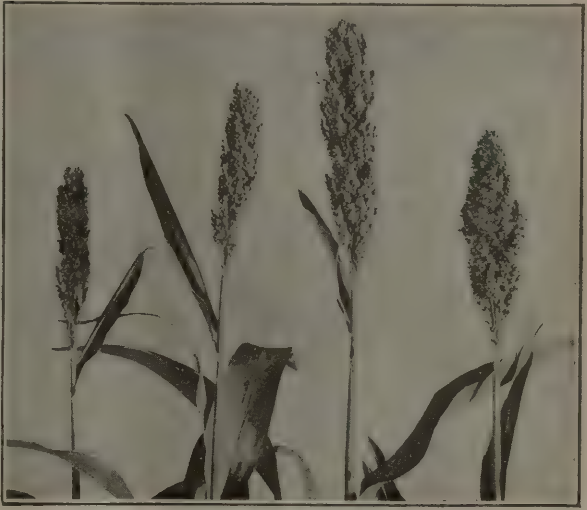

FIG. 12.—Loose and covered kernel smuts of sorghum on kafir, showing two sound heads of kafir (center) for comparison. Both of these smuts are readily preventable by disinfection of the seed.

MILLET SMUTS.

The smuts of millet are somewhat similar to those of the sorghums. The kernel smut of millet (fig. 13), however, occurs only on the spiked varieties (the foxtail millets), while the head smut, which resembles that on sorghums in appearance, is peculiar to proso, or hog millet. The former is readily prevented by the same treatment as for the kernel smut of sorghums. The head smut has been very rarely found in the United States, and but little is known concerning it. Some writers in Europe have claimed that it, too, can be prevented by treatment of the seed.

METHODS OF DISINFECTION.

MATERIALS, APPARATUS, AND FORMULAS.

Three general methods for disinfecting the seed of cereal crops are commonly in use, namely, treatment with formaldehyde, with copper sulphate, and with hot water. Other fungicidal or germicidal methods or substances may be used, but are either poisonous, less efficient, less readily available, more expensive, or for some other reason are not usually so satisfactory or so generally used. They will, therefore, not be considered here.

Whatever method is used, it is always profitable to clean and grade the seed thoroughly beforehand. Dirty sacks, bins, and machinery should be disinfected or scalded before using them for handling treated seed.

Formaldehyde.[1]

Formaldehyde, as usually sold, is prepared as a solution of formaldehyde gas in water. According to the United States standard of purity for interstate commerce, 37 per cent of the weight of the solution as sold must consist of formaldehyde gas. Some State laws require a 40 per cent solution. When these concentrated solutions are allowed to become very cold, a whitish substance, paraformaldehyde, will appear in them. This weakens the solution and, before using, it should be warmed until the paraformaldehyde disappears.

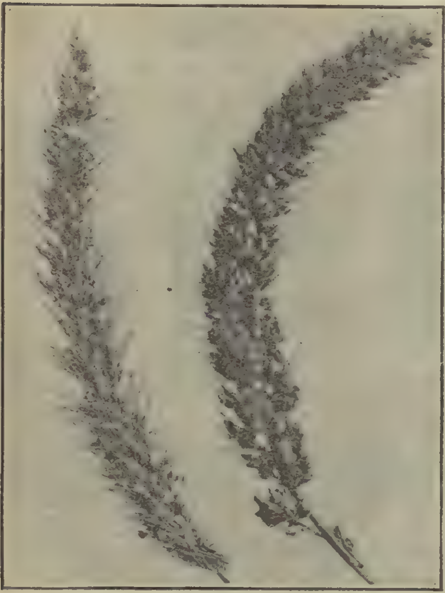

FIG. 13.—Kernel smut of millet (at right), with a sound millet head (at left) for comparison. This smut occurs only on the foxtail millets and not on proso (hog millet). It is not the same as the kernel smut commonly found on the foxtail grasses of the Eastern States.

A solution of formaldehyde in water when exposed to the air under ordinary conditions will become stronger, and hence more likely to injure the germination of the grain treated. Old solutions which have been used and have stood exposed for two or three days should therefore be discarded, not because they have lost their strength, but because they have gained in strength indefinitely and can not be brought again to proper strength for safe and dependable use.

Formaldehyde was discovered by Hofmann, a German chemist, in 1867, and has been used in disinfecting since 1888. In the United States it was first recommended for use on grains by Bolley, of the North Dakota Agricultural Experiment Station, in 1897. For use in preventing bunt in wheat, stem smut in rye, covered smut in barley, either of the smuts in oats, or the kernel smuts in sorghum (kafir, broom corn, etc.) and millet, it is very much the most convenient and effective fungicide known. It has the particular property of leaving no trace of its poisonous effect in the grain when dried. This, however, is not always an advantage (see p. 20).

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[1] Formalin is a term which has been much used to signify the commercial solution of formaldehyde. It has, however, been registered as a trade-mark by a German firm of chemists. For disinfecting purposes, the ordinary solution, which usually contains 5 to 10 per cent or more of wood alcohol in addition to the formaldehyde gas, is as good as the proprietary "Formalin."

The several methods of applying formaldehyde to seed grain are by (1) soaking, (2) dipping, (3) sprinkling, and (4) spraying. Except when using the first of these, all seed should be passed through a fanning mill and thoroughly cleaned before it is treated. This is particularly necessary with wheat and barley, and is always advisable even with the soaking process.

SOAKING.

With the possible exception of oats and rye, the thorough treatment of seed grain requires that, in addition to cleaning by fanning, it shall be soaked in an open vat or tub, so that it can be stirred, and the refuse rising to the surface, including unbroken, smutted kernels, can be skimmed off. Otherwise these false kernels, containing innumerable smut spores which are not injured by the treatment, become broken in subsequent handling and thus reinfect the seed grain before it is sown. Machines for the convenient and thorough performance of such a soaking process are on the market and will prove useful to large growers, particularly for use with wheat. Simpler and less expensive devices are shown in figures 14 and 15.

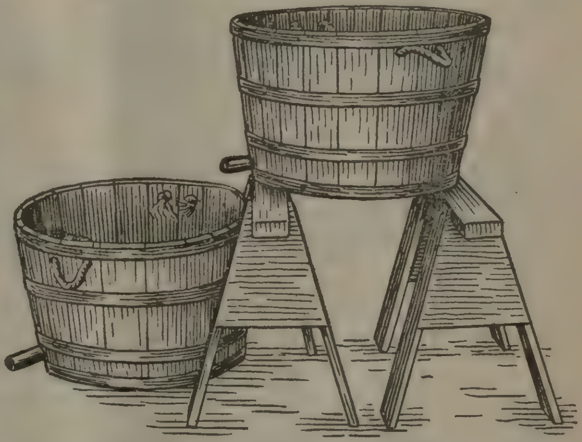

FIG. 14.—Simple apparatus for the soaking process, consisting of two half-barrel tubs, fitted with pine plugs and rope handles, and two sawhorses. The holes for the plugs are covered with screening. When the grain in the upper tub has been soaked long enough, the solution is drained into the lower tub and the grain spread out to dry. The position of the tubs is then reversed, more grain is poured into the solution, and the process repeated.

The period of soaking may be varied from little more than dipping, in which case the grain must afterwards stand wet in a pile, as in the sprinkling method (p. 19), to so long a soaking that the grain is thoroughly and uniformly disinfected when removed from the solution and may be immediately spread out to dry. In attempting to eradicate smut from a community, so as to avoid the necessity for treating the seed each year, this prolonged method should be used because of its thoroughness, even though it gets the seed so wet that it is troublesome to dry during cold or wet weather. A long period of soaking is especially to be preferred in the case of barley, because in this way losses from loose smut (p. 11) and stripe (p. 27) are more or less controlled, and also in the case of the sorghum crops, in which the small quantity of seed required and the semiarid conditions under which these crops are generally produced make the drying of the seed a simple matter. As a rule, however, it is undesirable to wet the seed grain any more than is necessary. For this reason the longer periods shown in Table I are not recommended for general use.

The strength of the formaldehyde solution, expressed as dilutions of the commercial (37 to 40 per cent) preparation, and the periods of soaking which are recommended for the different grains are shown in Table I.

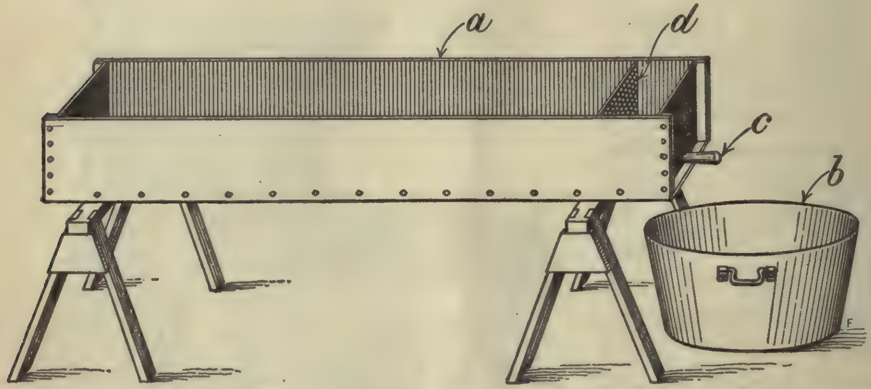

FIG. 15.—Simple apparatus for the soaking process, consisting of trough, tub, and sawhorses: *a*, Trough; *b*, tub; *c*, pine plug; *d*, perforated tin plate. The trough is filled two-thirds full with the solution and the grain added, stirred, and the floating refuse skimmed off. Drain the solution into the tub, shovel out the grain, replace the solution in the trough, and repeat the process.

TABLE I.—*Formulas for soaking treatment with formaldehyde.*

[Never use dirty sacks, bins, or machinery for handling treated seed without first thoroughly soaking them with strong formaldehyde (1 pint in 10 gallons) or scalding with boiling water. Read the section on seed injury, p. 24.]

Crop.	Dilution of solution.	Duration of treatment.	Remarks.
Barley	1 part in 320[a]	30 minutes to 3 or 4 hours.	Loose smut not wholly prevented.
Broom corn	1 part in 240[b]	2 to 4 hours	Head smut not preventable.
"Cane" (sorgo)	do	do	Do.
Corn			Treatment of seed does not prevent smut.
Emmer	1 part in 320	30 minutes to 1 hour	Loose smut not prevented.
Kafir	1 part in 240	30 minutes to 2 hours	Head smut not preventable.
Millet	do	do	Proso not included.
Oats	do	do	
Rye	1 part in 320	10 to 30 minutes	Rotate with other crops.
Spelt	do	30 minutes to 1 hour	Loose smut not prevented.
Sorghums	1 part in 240	2 to 4 hours	Head smut not preventable.
Sudan grass	do	do	Do.
Wheat	1 part in 320	10 to 30 minutes	Loose smut not prevented. See page 9, on soil infestation by bunt.

[a] Equivalent to 1 pint in 40 gallons, liquid measure.
[b] Equivalent to 1 pint in 30 gallons, liquid measure.

DIPPING.

In dipping, the seed grain, after thorough cleaning and grading, is usually placed in gunny sacks (seamless heavy cloth sacks are not satisfactory) which should be filled not more than half full and tied at the top. If the sacks are too full the grain can not be properly agitated so as to get it all thoroughly wet at the same time. After repeated dipping and agitation in the solution the sacks of grain are put where they will drain and dry enough so the seed will run freely through the drill. If not used within two hours (or at most over night) from the time of dipping, the seed should be spread out to dry and air, in order to stop the action of the formaldehyde. Wheat and rye are especially liable to injury if left wet too long.

This method is essentially only another way of carrying out the sprinkling method described below.

SPRINKLING.

The sprinkling method (see the title-page illustration) is almost a standard procedure for the treatment of oats and is also widely used for the other cereals. For the sorghum crops, where relatively small quantities of seed are concerned, the soaking process is to be preferred.

For sprinkling, the same strength of solution may be employed as for the soaking process (Table I), and the same precautions should be observed. Not more than a gallon of the solution will be required for a bushel of any kind of grain. Many use only half a gallon. Application is made with an ordinary sprinkling can while the seed is being shoveled over from one pile into another. The grain must be so well stirred that every kernel is thoroughly wet. It is then covered with sacks or other cloth wet with the formaldehyde solution and allowed to stand for a period before being spread out to dry or sacked for use. Oats and barley should remain wet in the pile for at least two hours or may be left over night. Wheat and rye, if treated by this method, are more likely to be injured by standing wet over night, but should be left covered for at least two hours.

SPRAYING.

The difficulty of drying the grain after treatment by the methods described above has recently been obviated by the use of a strong solution, in small quantity, which is sprayed on the seed grain in a very fine mist. This method has not been thoroughly tried with all the cereals, but its convenience commends it in practice, and it has proved satisfactory for oats in the Eastern States. A description [1] of the process is therefore given herewith.

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[1] Haskell, R. J. The spray method of applying concentrated formaldehyde solution in the control of oat smut. *In* Phytopathology, v. 7, no. 5, p. 381–383. 1917.

As the seed is being shoveled from one pile to another, each shovelful is sprayed with a solution consisting of one part of 40 per cent liquor of formaldehyde and one part of water. This solution is used at the rate of 1 quart to 50 bushels of seed. A small quart sprayer is a convenient one to use for the purpose. After the oats are all treated in this way they are piled in a heap and covered with blankets, canvas, or sacks to confine the vapor. At the end of five hours the seed may be uncovered and planted. As formaldehyde vapor acts as an irritant to the mucous membrane of the eyes, nose, and throat, the sprayer should be held down close to the pile and a circulation of air should be provided.

With the ordinary quart sprayer, one stroke of the piston will give enough mist, if properly distributed, for each shovelful of grain.

Special apparatus for the uniform application of formaldehyde gas, preferably in a jet of steam or vapor, to large lots of grain in an elevator can be readily devised. Several devices for this purpose have been patented and would prove particularly useful where a "dry" treatment is almost imperative, as in treating flaxseed to prevent wilt. Strictly dry treatments have not been found successful, since disinfection with formaldehyde gas appears to require some moisture.

Copper Sulphate.

A definite method for the use of copper sulphate (bluestone or blue vitriol) in the treatment of seed grain was described by Prévost, in France, in 1807, and it seems probable that the use of this or other copper salts was first practiced many years earlier. With the introduction and improvement of other methods for the chemical treatment of seed grain, however, particularly the formaldehyde method, the use of copper sulphate, which had become quite general, has been discontinued in many sections of the United States. This has been largely the result of its greater cost [1] and greater injury to germination and the development of the seedling. Formaldehyde is also more convenient to use, because metal containers of any kind can not be used for copper-sulphate solutions, since they will become corroded and the action will at the same time weaken the copper-sulphate solution. Moreover, the treated grain can be used for feeding purposes when disinfected with formaldehyde, but not when copper sulphate is used.

Copper sulphate has one distinct advantage, however, because of the fact that as the solution dries it leaves on the seed a deposit of the copper sulphate, which acts as a protection against reinfection from the soil or other source. It is for this reason more generally used on wheat than on other cereals, particularly in those Pacific Coast States where bunt infestation in the soil is serious (p. 9).

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[1] At this time (January, 1918) it has been some two years since copper sulphate sold for less than 10 cents per pound, and that only in carload lots. Small quantities can not be obtained for less than 25 cents per pound. This high price, coupled with the national need for conservation of compounds of both copper and sulphur, makes it especially desirable to avoid the use of copper sulphate for treating seed grain.

Soaking in an open vat or tub, dipping, or sprinkling—methods already described for the use of formaldehyde (pp. 17–19)—may also be used for the application of copper sulphate to seed grain. However, as noted above, the value of this treatment is chiefly dependent upon the fungicidal action of a more or less permanent coating of copper sulphate left on the seed, so that, inasmuch as the germination of the seed is likely to be injured, it is never desirable to leave the seed wet any longer than is necessary to get the surface of every kernel thoroughly wet with the solution, or, when soaking in an open vat, to remove the floating trash and smut balls. As soon as the application of the solution is completed, therefore, the grain should be dipped immediately in milk of lime, or sprinkled with it, to prevent injury to germination, and then spread out and raked over occasionally to hasten drying.

Solutions varying from 1 pound of copper sulphate to 5 gallons of water to 1 pound to 10 gallons are commonly used. The addition of common salt (sodium chlorid) to the copper-sulphate solution has been found to add considerably to its effectiveness, with no apparent increase in its tendency to injure the seed if lime is used afterwards. The salt is added at the rate of 1 pound for every pound of copper sulphate used.

To prepare milk of lime for use after the application of copper sulphate, slake 1 pound of quicklime and add enough water to make 10 gallons.

Hot Water.

Many variations of the use of heat for the prevention of smut, some of them of ancient origin, have been employed; but the standardization of the practice was not accomplished until Jensen, in Denmark, took up his studies of the hot-water process during the latter part of the past century. His methods, or such modifications of them as are believed to be most practicable, are here described under the following heads: (1) The short hot-water treatment, (2) the modified hot-water treatment, and (3) the long hot-water treatment, or pasteurization. The last two treatments are considered together, since one or the other is required in the case of loose smut in either wheat or barley.

THE SHORT HOT-WATER TREATMENT.

The short hot-water treatment will prevent only such diseases as are also preventable by chemical methods. While a certain amount of experience and equipment are necessary to its use, it has the advantage of general availability and cheapness. It is most useful for the treatment of the seed of the grain sorghums and broom corn, since higher temperatures may be used on these crops, and also because the relatively small quantity of seed needed may be uniformly and effectively treated with greater facility than in the case of the smaller cereals. As compared with disinfection by formaldehyde or copper sulphate, this method may be used with less danger of injury to germination in the case of grain which has been cracked or scratched in thrashing. Details of the treatment required for the different cereals are given in Table II.

TABLE II.—*Formulas for the short hot-water treatment.*

[Never use dirty sacks, bins, or machinery for handling treated seed without first thoroughly soaking them with strong formaldehyde (1 pint in 10 gallons) or scalding with boiling water. Read the section on seed injury, p. 24. Keep the hot-water bath agitated, so that the temperature will be equalized throughout.]

Crop.	Temperature of water.	Admissible range in temperature.	Duration of treatment.	Remarks.
	°F.	*°F.*	*Minutes.*	
Barley	129	126 to 130	10 to 15	Loose smut not prevented.
Broom corn	140	134 to 142	10 to 12	Head smut not preventable.
"Cane" (sorgo)	140	134 to 142	10 to 12	Do.
Corn				Treatment of seed does not prevent smut.
Emmer	132	130 to 135	10 to 15	Loose smut not prevented.
Kafir	140	134 to 142	10 to 12	Head smut not preventable.
Millet	140	134 to 142	10 to 12	Proso not included.
Oats	132	130 to 135	10 to 15	
Rye	132	130 to 135	10 to 15	Rotate with other crops.
Spelt	132	130 to 135	10 to 15	Loose smut not prevented.
Sorghums	140	134 to 142	10 to 12	Head smut not preventable.
Sudan grass	140	134 to 142	10 to 12	Do.
Wheat	132	130 to 135	10 to 15	Loose smut not prevented. See p. 9 on soil infestation by bunt.

On the average small farm seed grain, when given the hot-water treatment, may be handled as follows: Provide at least two screen-lined or cloth-lined baskets holding about a bushel of grain each; two or three barrels or tubs, as large as are available, for water; a good thermometer; and a supply of boiling water. The grain is placed in a basket, which is filled not over two-thirds full and plunged into one of the tubs or barrels full of hot water at the temperature indicated in Table II. This temperature must be maintained as closely as possible by the addition of hot water as needed. Less difficulty will be experienced in doing this if the quantity of water used is large as compared with the bulk of grain being treated, and also if the grain is first plunged for a minute into a preliminary hot bath prepared in another tub at a temperature about 10 degrees lower than is required for the treatment.

At the end of the period of treatment the basket of grain is transferred to cold water in the third tub, so as to terminate the action of the heat. This procedure is unnecessary, however, if the grain can be spread out to cool and dry *immediately*. If the temperature of the bath has been lower than that shown in the second column of Table II the treatment should accordingly be prolonged a few minutes; while if it has been generally too high, a corresponding shortening of the period of treatment is necessary.

On farms or at central treating plants where steam is available the hot-water treatment may be much simplified by regulating the temperature of the bath with a steam jet placed in the bottom of the tub or vat used. A cloth or screen tied over the jet will prevent the noise caused by the injection of steam. Automatic regulation of the steam supply by a thermostat could be readily provided in a central treating plant without much expense.

THE MODIFIED AND THE LONG HOT-WATER (PASTEURIZATION) TREATMENTS FOR WHEAT AND BARLEY.

The treatment on the farm of all the seed for the season's planting by either of these methods for the prevention of the loose smuts of wheat and barley is not usually feasible. The prevention of these smuts, therefore, can be accomplished best by treating a small amount of carefully selected and recleaned seed and using this to grow seed for the ensuing season. Such a seed plat should be large enough to provide more than twice as much grain as will be necessary for farm seed the following fall or spring. This will provide for a reserve stock of seed and also for loss in cleaning and selecting. The isolation of this plat from smutted crops of the same cereal is absolutely necessary, not only from crops on the owner's farm but from neighboring farms as well. The plat should be watched at heading time for smut which may have escaped the treatment, so that affected plants may be promptly removed and burned.

The equipment and general procedure for treating grain by the modified and pasteurizing processes are essentially the same as for the short process (p. 22). The prolonged soaking which is necessary for the prevention of the loose smuts of barley and wheat (pp. 10 and 11) is accomplished in different ways in the two methods; in the one, by soaking in cold water before treating with hot water, and in the other by using a lower temperature in the bath and prolonging the treatment.

The presoaking in the modified process should be continued for 4 to 6 hours. If the water used and the weather are warm, the period of soaking should be shorter than when using cold water during cool weather. After presoaking, the grain is handled as in the short hot-water process (p. 22) and is treated as follows: For wheat, 129° F. for 10 minutes (admissible range, 124° to 131° F.); for barley, 126° F. for 13 minutes (admissible range, 124° to 129° F.). Greater care is necessary in this process than in using the short hot-water treatment, for the danger of injury to germination is considerable. The preliminary hot bath and subsequent cold dip (p. 22), to insure that the treatment shall begin and end promptly as intended, can not be omitted in this modified procedure, and thorough agitation of the bath is essential. The period of treatment, moreover, must be shortened or lengthened as the temperature rises or falls below the definite point assigned—129° F. for wheat and 126° F. for barley.

The long hot-water treatment or pasteurization method may make use of the same kind of equipment as the other hot-water methods. Only one tub or vat is required, however. The treatment for wheat and barley is the same, i. e., 3 hours at 113° F.; admissible range, without change in the duration of the treatment, 111° to 115° F. In order to keep the bath agitated so as to equalize the temperature throughout, it is suggested that the basket or sack containing the grain be suspended by a rope from a beam or the limb of a tree, so it will hang in the water. It can then be moved about readily, and the rope can be twisted so that it will continue to turn for a time without attention. The advantages of this method lie in the greater safety to germination, in the greater certainty of prevention, and in the use of but a single bath. It is difficult, however, though not at all impossible, to maintain an almost constant temperature for so long a time.

It has been found entirely feasible to vary the temperature for pasteurizing at will between wide limits (105° to 120° F.) provided the duration of the treatment is varied accordingly within a range of 1½ to 6 hours. The satisfactory use of this wide range, however, requires that some other method than guessing be employed to indicate the period of treatment required. An instrument for this purpose has been devised and successfully used experimentally in rendering this treatment safe and certain, but it is not at present so standardized that it can be produced for general use.

During the application of either of these processes for the prevention of the loose smuts of wheat and barley, the grain must absorb about one-fourth of its original weight in water. In most grain-growing districts it is therefore necessary, if the prevention of these smuts is to be undertaken on a commercial scale, that it be done in connection with a central treating station where artificial drying facilities with forced draft can be installed. In using such an artificial drier, care must be taken not to dry at temperatures so high as to injure germination. It will be safer not to use temperatures above 150° F. after the grain is surface dry. The grain itself should not reach a temperature above 140° F., and if the circulation of air is inadequate temperatures as low as 110° F. will be injurious if long continued.

SEED INJURY.

The difficulty of avoiding injury to the seed from treatment that is too severe or from improper drying after treatment has undoubtedly had more influence in preventing the general spread of the practice of disinfecting seed grain than has the cost of materials or the difficulty of the treatment itself.

Drying too slowly after treatment is likely to result in injury to germination, not only because of the danger of heating or molding, but also because of the prolonged action of the formaldehyde, hot water, or other agent used. On the farm an excellent arrangement for drying is an elevated, latticed platform covered with canvas. The wet grain is spread out on this in a layer 2 or 3 inches thick and stirred occasionally to hasten the drying. When drying conditions are bad, it is generally advisable and also more convenient to sow as soon after treating as the grain is dry enough to run freely. If the grain is too moist to feed well in some seeders or drills, this may be remedied by mixing in land plaster, which will take up the surface moisture. In the case of spring grain treated during cold weather, prompt seeding is especially desirable, because of the danger of freezing the moist grain and killing it.

Poor stands attributed to seed injury often are really due to the use of too little seed. The treated grain is always more or less swollen, and the rate of seeding must therefore be correspondingly increased. The increase required can be estimated by noting the increase in bulk of all, or of a given portion, of the seed. It usually amounts to at least one-fifth of the dry grain and may even exceed one-half if the grain is shriveled. In addition to this an increase may also be required on account of reduced germination.

Growers of grain in the arid sections of the West have found that seed is frequently injured seriously even when carefully treated. This is generally because the very dry grain has been cracked or scratched over the germ in thrashing and so is almost as readily killed by the treatment as are the smut spores. The remedy is to run the cylinder at a low rate of speed when thrashing grain to be used for seed, so as to avoid injuring it. The thrashing of seed grain should be done, if possible, when the grain is slightly damp, as from dew in the morning, for it will not then be so easily injured. If only cracked seed is available, the hot-water process will injure it less than chemical treatment.

More complaint of injury to seed grain, particularly wheat, by the chemical treatments for smut has developed in districts where the softer wheats are grown. This situation is probably the result of several factors. Under the same conditions the soft wheats are undoubtedly more liable to injury in thrashing than the hard wheats. Moreover, the likelihood of weevil injury in the South would be reflected in the effect of treatment on germination, and in addition the higher temperatures prevailing, particularly when seed for fall planting is treated in the summer, would tend to increase the action of the chemical used, and more especially of formaldehyde. Care in using cold water to make up the solution or in shortening the time of treatment would, under such conditions, reduce but not eliminate the danger of injury.

Seed may differ in its susceptibility to injury, for several reasons. Thus, in the case of sorghums, those varieties in which the seed does not thrash out of the chaff (such as broom corn and sorgos) may be given a more severe treatment than those in which the grain is uncovered (kafir and most other grain sorghums). In fact, every lot of seed grain has its own peculiarities. One European authority, recognizing this fact, recently made arrangements for growers to send in small samples of the grain which they wished to treat. With these he experimented until he could advise the farmer exactly how to treat his seed to avoid injuring it. No such facilities are provided in this country, but those who have had difficulty with seed injury would do well to do a little experimenting for themselves. It is often a serious risk to sow treated grain without first testing it for germination and then increasing the rate of seeding as necessary to get a stand.

The seeds of the small grains may easily be tested for germination. Two dinner plates and a piece of cloth four times the size of the plates (fig. 16) are all that is needed. Wring the cloth out of clean water just dry enough so it will not drip. Fold it once and lay it on one plate. Count out 100 seeds just as they come, and place them on the cloth so the seeds do not touch each other. Fold the loose end of the cloth over the seeds and cover with the other plate. After three days, open and remove and count the sprouted seeds. Moisten the cloth if necessary and let stand two days longer. Then open and remove and count the sprouted seeds, continuing until all the seeds have either sprouted or decayed.

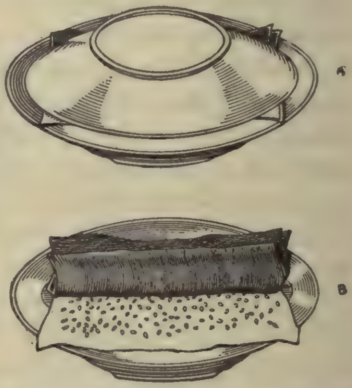

FIG. 16.—Homemade seed germinator: *A*, Closed; *B*, open.

If the test shows poor germination and there is reason to think the seed has not been injured by the treatment, send samples of both treated and untreated grain to your State agricultural experiment station or to the United States Department of Agriculture and ask that they be tested.

Seed grain which is low in germination because of injury by treatment is nevertheless more desirable for seeding than untreated, diseased grain. A low percentage of germination in untreated seed is generally an indication of careless handling, bad storage conditions, or old seed; in short, of reduced vitality, due oftentimes to the presence of scab and similar diseases. From such seed a good healthy stand can not be obtained, even with a heavy rate of seeding. With seed of good quality, however, which has been freed from diseases but is low in germination because of treatment that was somewhat too severe, an abundant stand of healthy plants may be obtained by increasing the rate of seeding to the required extent, as indicated by a germination test. This is especially true if the hot-water or formaldehyde methods of treatment have been used. Copper sulphate may weaken the plants if the seed is not properly limed after treatment.

DISINFECTION AND YIELD.

Yield is, of course, the first consideration in the matter of profits from the disinfection of seed grain. Careful experiments both in this country and in Europe show that the disinfection of the seed frequently increases the yield more than would be expected from simply replacing the smutted heads with sound ones. The greatest gain is usually obtained from the use of the formaldehyde or the hot-water treatment. Increases of over 4 bushels per acre have been found in spring wheat in which only a little over 1½ bushels were actually destroyed by smut. Similarly, oats have given added yields two to five times as great as the quantity of grain which was smutted in the fields not treated. These results have been largely corroborated by the experience of county agents in demonstrations of the formaldehyde treatment for oats.

This added increase, when it occurs, is probably chiefly due to the fact that the grain is affected by other, less evident seed-borne parasites than smut,[1] which are as effectually checked as the smut by the treatment given. Barley, for instance, is affected by a disease called stripe, which can be largely controlled by the soaking treatment with formaldehyde (p. 17). In Europe treatments of seed grain are often employed when no smut is present, for the sole purpose of eliminating this type of disease and the losses caused thereby.

While smut in the cereal crops is never directly caused by any condition of the weather or soil, the amount occurring in the crop is always more or less influenced by such factors. The conditions during the growing period of the crop, particularly in the soil at seeding time, must be favorable to the smut parasite if the latter is to be successful in producing the disease, i. e., in reproducing itself. Smut losses might therefore be largely avoided if the conditions at the time of seeding could be determined beforehand. While this, of course, is impossible, early seeding for both spring and winter grains[1] will usually reduce the disease materially, and it is because of this interference of weather conditions that growers are frequently in a position to contend that their crops are not affected by smut, when, as a matter of fact, it is present every season. The grower is, of course, concerned only when he loses most of his crop, i. e., when it happens that the season has favored infection at the time of seeding and the yield is very perceptibly reduced. To avoid this risk of loss in yield he must treat his seed every year, for the presence of ever so little smut in a field is a menace to the profitable use of seed from that field for producing another crop.

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[1] Rust on any of the cereals is not known to be seed borne and hence is not to be included here among those diseases which are partially or wholly prevented by seed treatment.

It is true that community cooperation and the necessary legislation might eventually eliminate the smuts from a grain-growing district, so that treatment would not have to be repeated each season. Such a condition, however, does not now obtain in any district of which the writers have knowledge. Even if an individual farmer should succeed in producing a perfectly clean crop of grain, he would, unless isolated and using his own thrashing rig, be likely to find the disease as bad as ever in a year or two. Under such conditions the growing of varieties resistant to smut is the only way in which the necessity for treatment can be avoided, and such varieties are unfortunately not generally available for all the cereal crops or for all sections of the country.

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[1] Very late spring and fall seedings frequently show less smut than those sown on an average date, but this is not of practical importance in most sections where grain is grown, since other reasons obtain for not seeding at this time.

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COMMON WHITE GRUBS

JOHN J. DAVIS

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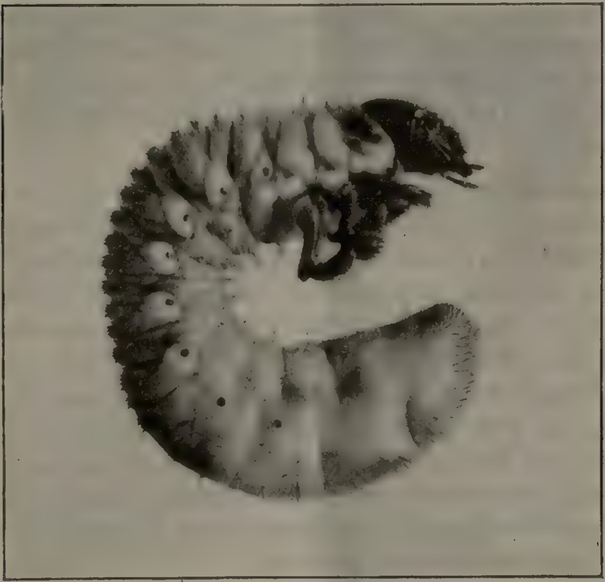

FARMERS' BULLETIN 940

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C.   Issued July 18, 1913, as No. 543; revised,   May, 1918

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WHITE GRUBS, the young of May beetles, are capable of devastating, and frequently destroy, large acreages of farm crops by eating the roots and underground portions. The crops damaged include two of our most important staples, namely, corn and potatoes. The adults—the beetles—eat the leaves of certain trees.

These insects require three years to complete their life cycle and usually only one brood is destructively abundant in a given locality. An abundance of May beetles one year indicates an abundance of grubs the following year. The pictorial diagram on pages 14 and 15 shows the life cycle.

It should be remembered that injury from white grubs, as well as from many other pests of farm crops, can be prevented by correct farm practice, but that after corn or any field crop has become infested with them it is impossible to prevent further injury to that particular crop.

Records of definite broods have been obtained for the Northern States and there it is possible usually to be warned one or more years in advance of their appearance.

For brief practical directions regarding what to do to combat each stage of the white grubs, consult the table on page 28.

COMMON WHITE GRUBS.

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WHITE GRUBS AND MAY BEETLES.

THE COMMON WHITE GRUBS, OR "GRUBWORMS" as they are often called (see title-page illustration and fig. 1), are the young of the May beetles or "June bugs" (fig. 2). They feed on the roots of various plants and the tubers of the potato (fig. 1) and have been recognized for years as serious pests, especially to corn and timothy, but also to the strawberry and potato, to recently transplanted roses, and to nursery plantings, particularly those of conifers. The adult insects (the beetles) eat the leaves of oak, ash, hickory, poplar, elm, willow, locust, hackberry, walnut, and other trees, and when abundant sometimes completely strip large tracts of timber. The most destructive work, however, is that of the grubs, which often results in the complete loss of crops where the outbreaks occur. Though grubs show a preference for certain food plants, from present information the grubs of different species do not appear necessarily to have different food habits. There are no authentic records of injury to such crops as alfalfa and clover, and from all observations small grains[2] are less attacked and injured than are corn, timothy, strawberries, beans, potatoes, and conifer seedlings.

OUTBREAKS OF WHITE GRUBS IN 1912 AND 1915.

Probably the most serious outbreaks of white grubs in the history of American agriculture occurred in 1912 and 1915, following an abundance of May beetles in 1911 and 1914, respectively. Injury was reported from almost every section of the country north of the Ohio

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[1] *Lachnosterna* spp.

[2] Winter wheat is severely injured quite regularly in the fall of the year in Kansas and Oklahoma by white grubs of one of the plains May beetles (*Lachnosterna lanceolata* Say). This insect, however, has habits and life history quite different from those of the common May beetles under discussion.

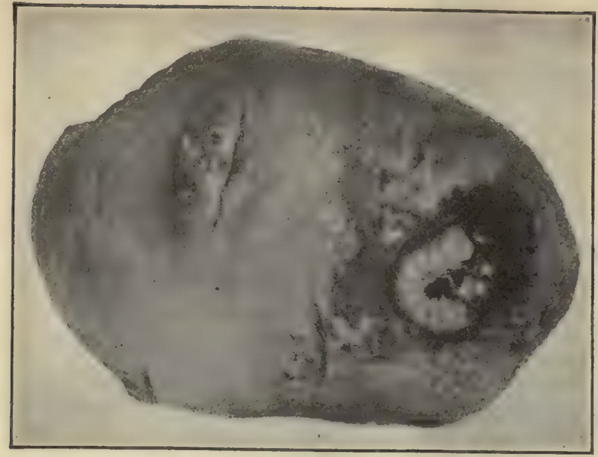

FIG. 1.—White grub working in a potato tuber, Tabor, S. Dak., 1912.

River and westward to South Dakota (see fig. 3). In the West the center of abundance was in southwestern Wisconsin, while in the East it seemed to be located in northeastern Pennsylvania and southeastern New York. Infestation occurred, however, as far west as Tabor, S. Dak., and though no serious general injury was found west of eastern Iowa there were scattered occurrences in western Iowa and southern Minnesota. Throughout the southern third of Wisconsin and in northern Illinois the grubs were abundant, especially in the western portion of these sections. Many infestations were also reported from southern Michigan and scattered ones from northern Indiana and eastward through Ohio.

In the worst infested districts it was not unusual to find from 40 to 60 white grubs in a single hill of corn. Indeed, in a cornfield near McGregor, Iowa, which had been planted to timothy the previous year (1911), 77 2-year-old grubs were found in an area only 2½ feet square and 5 inches deep. This really represented an area less than that usually occupied by a single hill of corn, for the hills in this field were 3½ feet apart.

From a survey of the infested territory in Iowa (fig. 4), Wisconsin (fig. 5), and Illinois (fig. 6), made in 1912, and from reports of farmers and others, we have a very

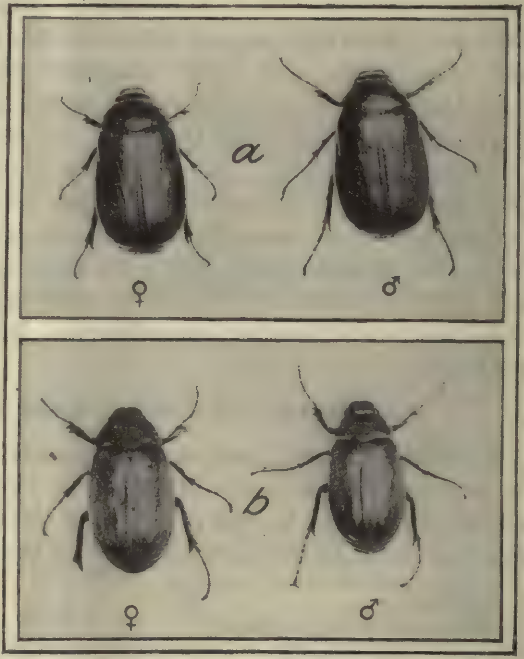

FIG. 2.—Typical examples of May beetles: *a*, *Lachnosterna anxia (dubia)*; *b*, *Lachnosterna ilicis*.

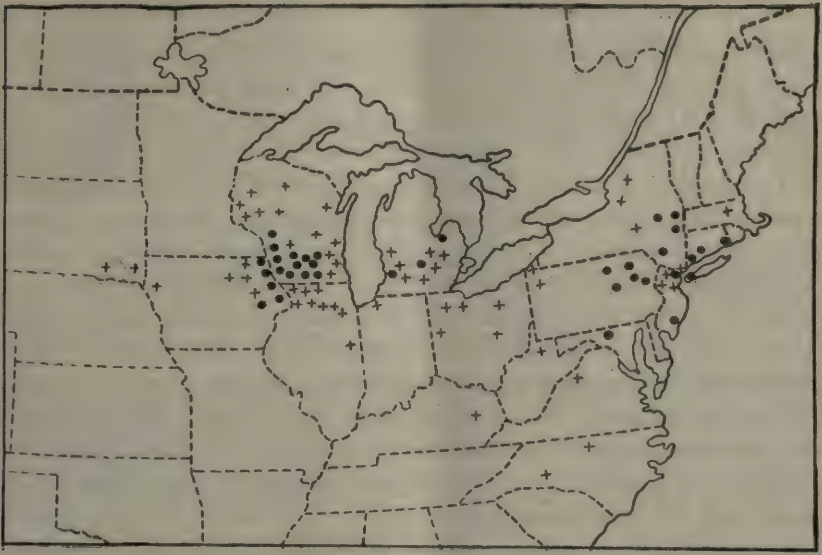

FIG. 3.—Map showing the invasion of white grubs in 1912. The black dots indicate counties known to have been generally infested; the crosses, those known to have been infested more or less.

conservative estimate of the damage to corn, timothy, and potatoes in these States aggregating not less than $7,000,000. The damage to the same crops in the other infested areas could not have been less than $5,000,000, which brings the total loss due to white grubs in 1912, exclusive of damage to strawberries, nursery stock, lawns, and miscellaneous crops, to not less than $12,000,000. A similar survey in 1915 showed a slightly smaller amount of apparent injury, although the beetles the preceding year were noticeably more abundant than in 1911 and the grubs were more numerous in 1915 than in 1912. The smaller amount of injury may be accounted for by the abnormally wet season which prevailed in this area in 1915, preventing the injury to crops and pastures which was so evident in 1912.

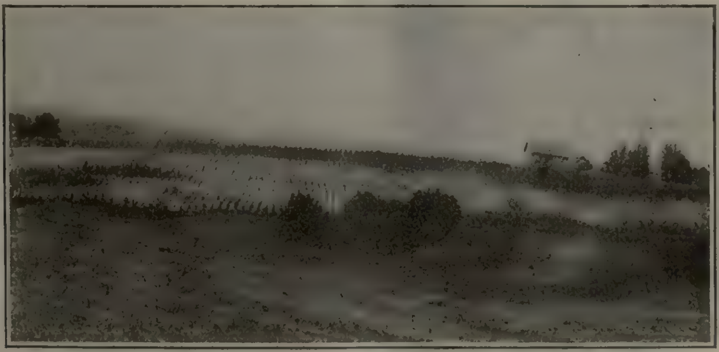

FIG. 4.—A 60-acre cornfield completely destroyed by white grubs, Farmersburg, Iowa, 1912.

POSSIBILITY OF AN OUTBREAK IN 1918.

May beetles were unusually abundant in 1908, the grubs causing much damage in Wisconsin, Illinois, and other localities in 1909 and again in 1912 and 1915, the damage being more pronounced in these localities in 1912. The beetles were very abundant in the spring of 1911 and again in 1914. This fact, together with the life-history cage experiments made by the Bureau of Entomology, gives conclusive evidence that the life cycle of the more abundant and injurious species in those localities is uniformly three years. In the fall of 1916 the recently changed beetles were found very abundant in newly plowed ground in the white-grub areas just mentioned, but in the spring of 1917 the beetles did not appear until nearly three weeks after their normal date of emergence. Even after they had issued, the intermittent cool weather prevented them from completely defoliating large areas of timber, as they did in 1914. Present observations indicate that the grubs will be less abundant in 1918, but they will be sufficiently numerous to cause much damage, especially if the season should be dry.

BROODS OF MAY BEETLES.

For the areas bounded roughly by the latitudes of northern Kentucky and southern Minnesota and from South Dakota on the west to Connecticut on the east the injurious and abundant species have a three-year life cycle, and the broods occurring in each of the three years have been designated as broods A, B, and C, respectively. The brood issuing as May beetles in 1914 and appearing as destructive grubs in 1915 is brood A (fig. 7). This is by far the most abundant of all

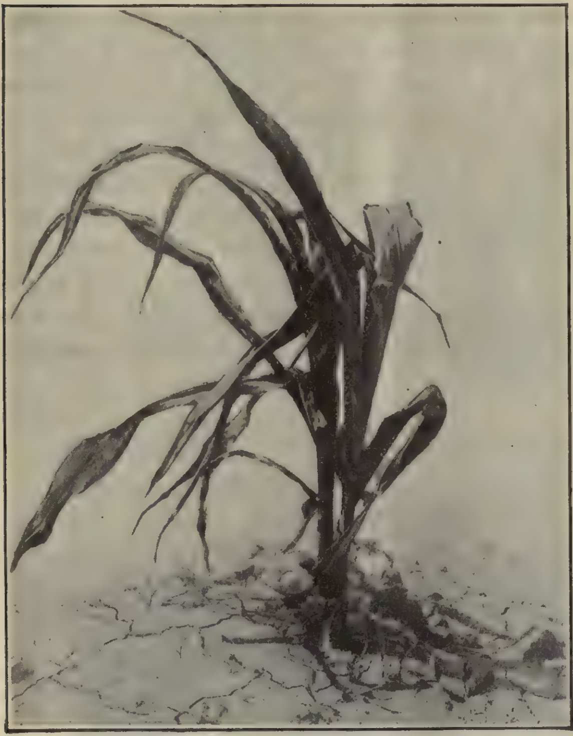

FIG. 5.—Individual corn hill showing characteristic white-grub injury, Platteville, Wis., August, 1915.

known broods and is the one discussed under the preceding headings. The second brood (brood B), of which the beetles appeared in 1915 and the grubs in 1916, is of little consequence at present. The third brood, known as brood C (fig. 8), was active in the beetle stage in 1916 and the grubs destructive and abundant in 1917 in a few comparatively small areas.

LIFE HISTORY AND HABITS.

All of the commoner species of May beetles have been reared from egg to adult at Lafayette, Ind. There the life cycle is three years, except in the case of several of the less important species. In the latitude of northern Wisconsin, where grubs of May beetles[1] are destructive to young conifers, the cycle is four years, and in the southern latitudes of Texas the period from egg to adult seems to be two years for most species. In the case of all of the common species occurring at Lafayette and northward the grubs change to adults in the fall, passing the winter in the soil as beetles and emerging the following spring. In several species[2] occurring in the latitude of southern Indiana and southward (species which appear late in the season and after the early appearing May beetles have about disappeared)

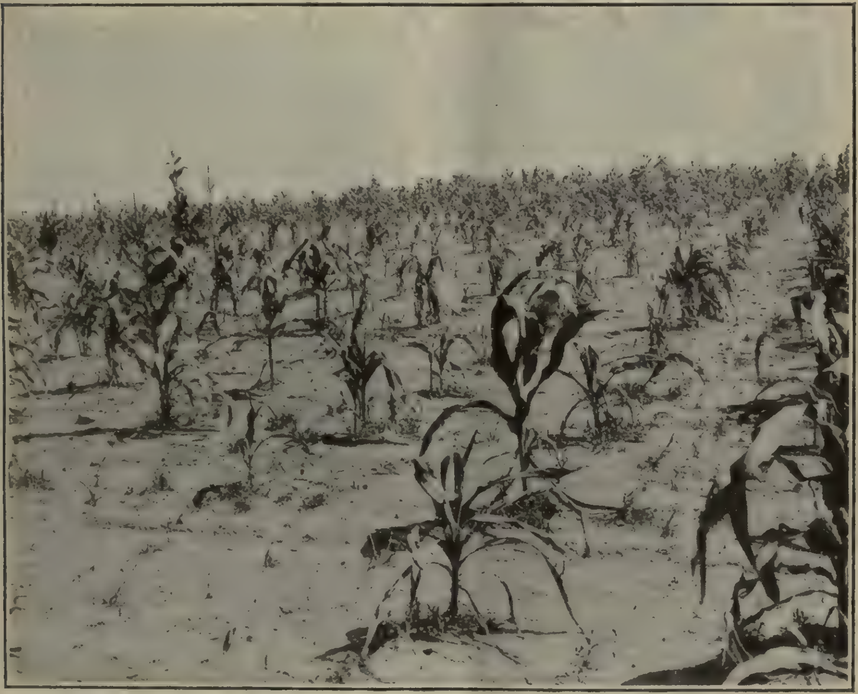
FIG. 6.—Cornfield injured by white grubs, Seward, Ill., August, 1915.

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[1] *Lachnosterna drakii* Kirby (*grandis* Smith) and *L. anxia* Le Conte (*dubia* Smith).

[2] *Lachnosterna ephelida* Say, *L. forbesi* Glasgow, *L. quercus* Knoch, and others.

pupation and subsequent emergence as adults takes place in the spring instead of in the fall.

A résumé of the life of the injurious generation of 1915 is as follows: Eggs (fig. 9) deposited by the female beetle in the spring of 1914 hatched three or four weeks later, and the young grubs fed the first season on decaying and living vegetable matter in the soil. As winter approached they protected themselves from the cold by burrowing deeper into the ground, remaining there inactive until the spring of the following year (1915), when they returned to a position near the surface, feeding on the roots of such crops as were available. In this the second year they did the maximum amount of damage. In the fall they again went deep into the soil, returning near the surface of the soil in the spring of 1916, where they fed as before on the plant roots until about June. Thus two full years were passed in the grub stage in the soil (fig. 10) and during this time they molted twice previous to molting for the pupa stage. They then prepared oval earthen pupal cells in the ground, became more or less inactive, and later changed to the pupa or true dormant state (fig. 11). The adult beetles (fig. 2), which emerged from the pupæ a few weeks later, remained in the pupal cells over winter and emerged the following spring (1917) to feed and mate in the foliage of the trees and shrubs and to deposit their eggs in the soil for another generation. The complete life cycle of the insects is shown in diagram in figure 14.

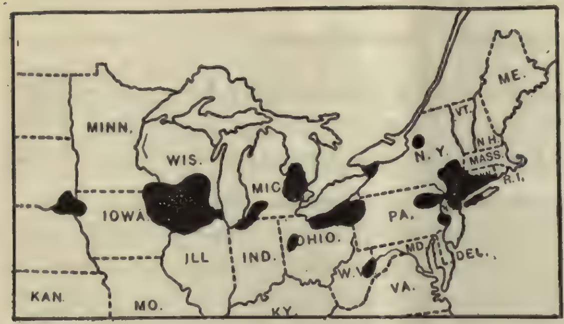

FIG. 7.—Map showing area of greatest abundance of "Brood A" of white grubs.

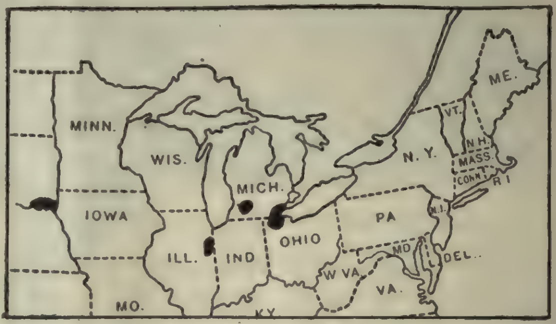

FIG. 8.—Map showing area of greatest abundance of "Brood C" of white grubs.

Unlike the grubs, the beetles of the different species differ as a rule in their food preferences. Certain species feed almost exclusively on the oak, others prefer the ash, and some feed indiscriminately. The trees which they ordinarily frequent in the Northern States are the oak (white and burr oaks in preference to red and black oaks), hickory, poplar, elm, willow, locust, hackberry, ash, and walnut. In certain localities the pine seems to be the preferred food. At Columbia, S. C., two species[1] have been found feeding on the longleaf pine by preference, and similar observations for these two species as well as for another[2] have been made in Alabama.

In the latitude of Indiana May beetles make their first appearance the last of April or first of May and continue to be present until the first or middle of July, the period of greatest abundance being between the middle and last of May. They swarm to the trees at dusk and remain there feeding and mating till just before dawn, when they return to the soil, only to reappear the following evening.

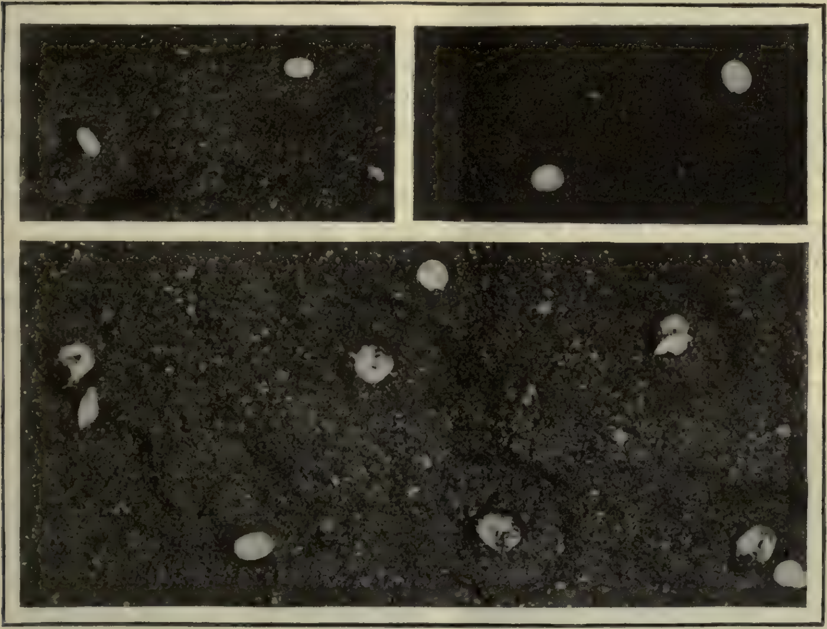

FIG. 9.—Eggs of white grubs in their natural cells: Upper left, immediately after deposition; upper right, six or seven days later; below, white grubs hatching.

When abundant the beetles are capable of defoliating large acreages of timber (figs. 12 and 13). In 1911, and again in 1914, 40-acre tracts of timber were completely defoliated by the beetles in southwestern Wisconsin, northeastern Iowa, northern Illinois, and southern Michigan, and the dropping of excrement and of detached leaves at night, when the beetles were feeding, sounded like hail. The beetles, in the years of abundance, were attracted to street arc lights in great swarms, and in one small town in southwestern Wisconsin the beetles accumulating beneath the 10 arc lights of the town were hauled away each morning for a period of 10 days or two weeks by the wagon load.

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[1] *L. prununculina* Burmeister and *L. luctuosa* Horn.

[2] *L. micans* Knoch.

The beetles (fig. 2) prefer to deposit their eggs in ground covered with vegetation in the immediate vicinity of timber, usually choosing for this purpose the more elevated parts. The preference in oviposition therefore has an important bearing on the control practices, for the grubs ordinarily are found most abundant in the higher portions, especially near wooded tracts, of fields of timothy (fig. 10) and bluegrass sod, or in any ground which during the previous year was in one of these crops or in small grain, or any other ground which was covered with vegetation excepting clover during the flight of the beetles.

The eggs (fig. 9) are pearly white. When first laid they are elongate, measuring about one-tenth inch in length, but six or seven days after oviposition they become swollen and almost spherical. They are deposited in the soil at a depth ranging from 1 to 8 inches, within oval cavities in the center of balls of earth, the particles of earth forming the balls being held together by a glutinous secretion supplied by the female beetle.

After hatching the very young grubs seem to prefer decaying vegetation, although under certain conditions, especially when they are very numerous, they will attack living roots. This was the case in Wisconsin in 1911, when the young grubs, only about 2 months

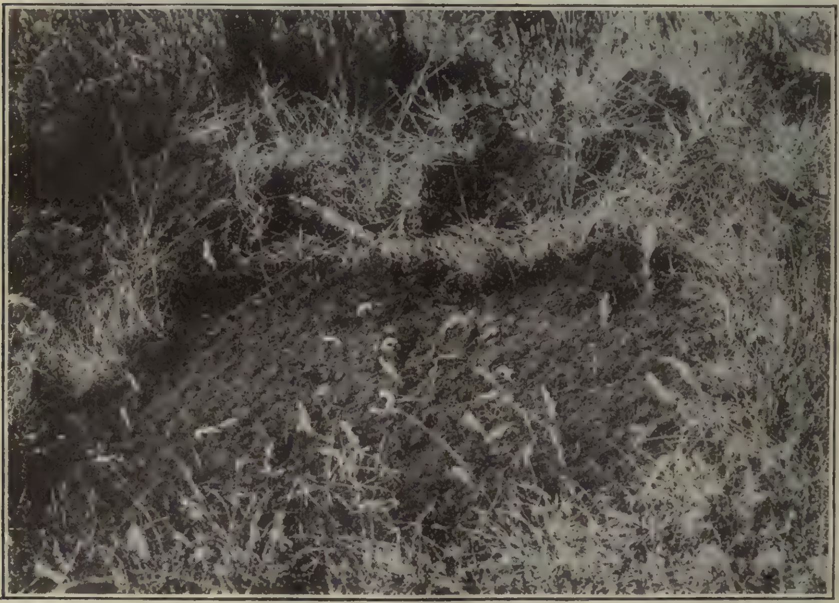

FIG. 10.—A piece of sod overturned to show the white grubs underneath, Lancaster, Wis., 1912.

old, damaged timothy fields (fig. 10). The grubs do the greatest amount of damage in their second year, and to the early plantings in their third year.

GRUBS LIKELY TO BE MISTAKEN FOR COMMON WHITE GRUBS.

It is important that the grubs of May beetles should not be confused with similar but harmless grubs and with other grubs which may be injurious but which, because of different habits and life history, require different methods for their control. Probably the most universal mistake is the general belief that the common white grubs of the field and the white grubs found in manure heaps and rotten logs are identical. *The grubs of May beetles are not known to breed in manure or refuse of any kind.* The most common grubs found in manure in the Northern States are the immature forms of certain brown beetles[1] which, like the May beetles, frequent lights, and would doubtless be mistaken for the latter by an inexperienced person, but unlike the latter the beetles do not feed on the foliage of plants. The May beetle grubs (fig. 15, *a*) may be distinguished from the manure grubs (fig. 15, *b*) and from most other grubs by the presence of a double row of more or less conspicuous spines along the median line on the underside of the last body segment.

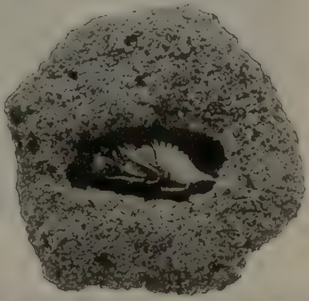

FIG. 11.—White-grub pupa in earthen cell. Natural size.

Another grub commonly mistaken for that of a May beetle is the young of the southern green June beetle, which frequently has been reported as indirectly injuring grass and other vegetation, including alfalfa, in localities south of the latitude of northern Kentucky, or even farther north along the Atlantic coast. The grub of the green June beetle seems to prefer soils more or less heavily fertilized with animal manures, and, besides, entirely unlike the common white grubs, it makes definite burrows which usually open at the surface and which it may inhabit continuously for longer or shorter periods of time. For this reason grubs of this species will come to the entrance of their burrows and even crawl out upon the ground when the land is flooded with water. This characteristic also offers a satisfactory means of controlling the grub of the green June beetle when in lawns or small areas. Again, this grub may be distinguished from the true white grubs by its general appearance and especially by its peculiar and characteristic method of crawling on its back when placed on the surface of the ground.

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[1] *Ligyrus gibbosus* DeGeer and *L. relictus* Say.

[2] *Cotinus nitida* Linnaeus.

NATURAL ENEMIES.

The white grubs and May beetles are preyed upon by numerous birds, mammals, and insects, all of which are more or less useful in reducing their numbers. Probably the most important of the natural enemies are the birds, especially crows and crow blackbirds. Fields of timothy sod have been literally overturned by crows in their search for grubs (see fig. 16), and in some fields the grubs were almost exterminated by them. Crows have often been observed following the plow in infested fields, eagerly picking up every grub that was unearthed. In one instance a single blackbird was observed to eat many grubs, apparently its full capacity, and then gather as many as it could hold in its beak and fly away. In this case the bird destroyed in all 20 grubs in 1 or 2 minutes. Besides crows and blackbirds, practically all of the common birds feed on white grubs or their adult forms, the May beetles. The U. S. Biological Survey has found these insects in the stomachs of 78 species of birds and 2 species of toads.

All farm fowls are fond of these insects and where possible should have the run of infested fields at the time of plowing. The turkey especially is valuable in this respect. The writer has seen infested timothy and sod fields thoroughly scratched up by these birds in their search for grubs. Chickens seldom search unplowed fields for grubs but if permitted to follow the plow will eagerly pick up every grub or May beetle exposed.

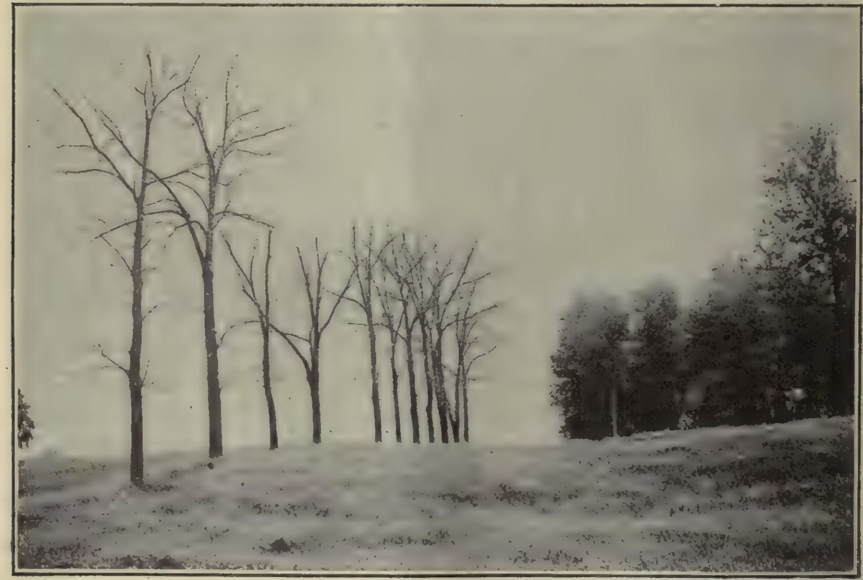

FIG. 12.—Walnut and soft maple, the former defoliated by May beetles, Galena, Ill., May 31, 1914.

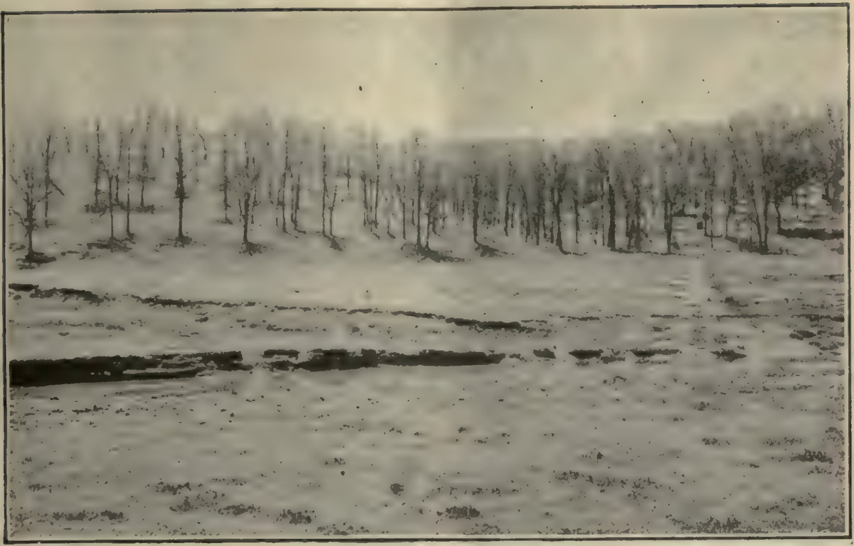

FIG. 13.—Hickory and oak timber defoliated by May beetles, Platteville, Wis., June 1, 1914.

Among the native mammals which feed on the grubs the skunk is probably the most valuable,[1] and, indeed, some farmers have gone so far as to attribute the increase in these insects to the decrease in numbers of skunks, which are being rapidly killed off by the trappers. In northeastern Iowa many large land-owners observed the grub-eating habits of the skunk during the recent severe outbreak, and have signified their intention from now on of protecting this friend of the farmer.

A large number of predacious and parasitic insects have been studied. Of these it is probable that such common and generally distributed forms as certain black digger wasps,[2] and another wasp,[3] are among the most beneficial.

The Tiphia wasp larva, after devouring the white grub, forms a characteristic cylindrical-ovate, light brown, woolly cocoon about three-fourths inch in length (fig. 17), and from this the jet black digger wasp emerges the following spring or summer. The cocoon of the Elis wasp (fig. 18) differs from the Tiphia cocoon (fig. 17) in that it is elliptical, slightly longer, of a darker brown, and comparatively smooth. The adult emerging therefrom is about the same size as the Tiphia wasp, or slightly larger, and the black abdomen is transversely striped with yellow. The cocoons of both of these parasites are frequently turned out by the plow, especially in fields badly infested with white grubs. The larvæ of flies,[4] parasitic on grubs, are numerous in certain localities, but since they are living within live grubs in fall, winter, and early spring, they are seldom noticed behind the plow. The larvæ of robber flies,[1] which prey upon white grubs, are slender, shining white, pointed at both ends, and about an inch and a half in length when full grown (fig. 19). They have a life cycle corresponding to that of the common white grubs in that they require three years to complete it. In certain sections of Wisconsin, Michigan, and New York they undoubtedly have been very important in minimizing the destructiveness of the grubs. When mature they issue as large flies commonly known as robber flies, bee killers, etc., and in this stage of their life are predacious on many kinds of insects. Certain parasitic flies[2] (fig. 20) attack only the beetle, usually depositing the egg within its body with its needle-like ovipositor as it flies from leaf to leaf or to the ground at night. The larva hatching from the egg gradually kills the beetle, although often the latter, if a female, is capable of depositing eggs for some days after being parasitized. Certain two-winged flies,[3] are similarly parasitic on the adult beetle but they oviposit on the beetle when it is quietly feeding on foliage at night.

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[1] The domestic hog is the most efficient of all grub destroyers where it can be utilized. It is fully discussed in this connection under "Methods of control," p. 17.

[2] *Tiphia* spp.

[3] *Elis* sp.

[4] *Microphthalma disjuncta* Wiedemann and *Ptilodexia tibialis* Desvoidy.

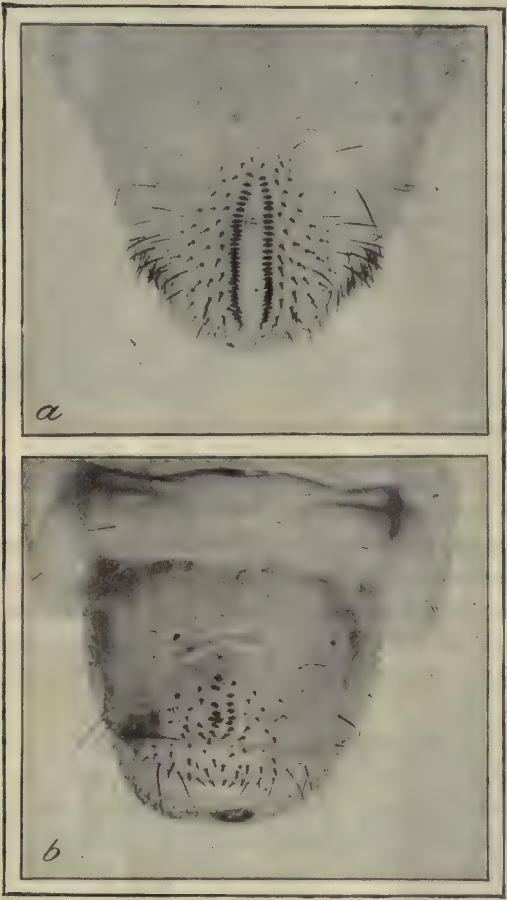

FIG. 15.—Last segments of the larvæ of (*a*) a common white grub and (*b*) a grub frequently found in manure.

Several fungous, bacterial, and animal parasite diseases have been reported attacking the grubs and beetles. Occasional outbreaks of these diseases have been observed, and it is highly probable that they serve as valuable natural checks periodically when conditions are favorable. In Europe certain of these diseases have been artificially grown and used to destroy the grub, but there seems to be a divergence of opinion as to their value when used in this manner. The experience of the writer indicates rather strongly that they can not be introduced artificially with satisfactory results except under favorable weather conditions.

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[1] *Promachus vertebratus* Say and *P. fitchii* Osten Sacken.

[2] *Pyrgota undata* Wiedemann and *P. valida* Harris.

[3] *Cryptomeigenia theutis* Walker, *Eutrixa exile* Coquillett, and *Biomyia lachnosternae* Townsend.

METHODS OF CONTROL.

All of the general farm practices here discussed and recommended are preventive rather than remedial, for once white grubs are present in a field of corn or other crop of large acreage there is no practical means as yet known of protecting that particular crop from their ravages. On the other hand, certain cultural and other practices will minimize greatly the damage in succeeding years.

UTILIZING HOGS AND POULTRY TO DESTROY GRUBS.

The practice of "hogging off" corn, thereby saving the labor and expense of harvesting and marketing the crop and also producing more pork from the crop, is becoming a common farm practice, the value of which has recently been repeatedly demonstrated. The utilization of hogs for the destruction of soil-inhabiting insect pests, more especially of white grubs and cutworms, however, has received little attention and seldom has been applied consistently, although pasturing hogs in grub-infested fields has been practiced occasionally for the last hundred years. The use of poultry is somewhat more restricted, since it can be utilized only when ground is being plowed

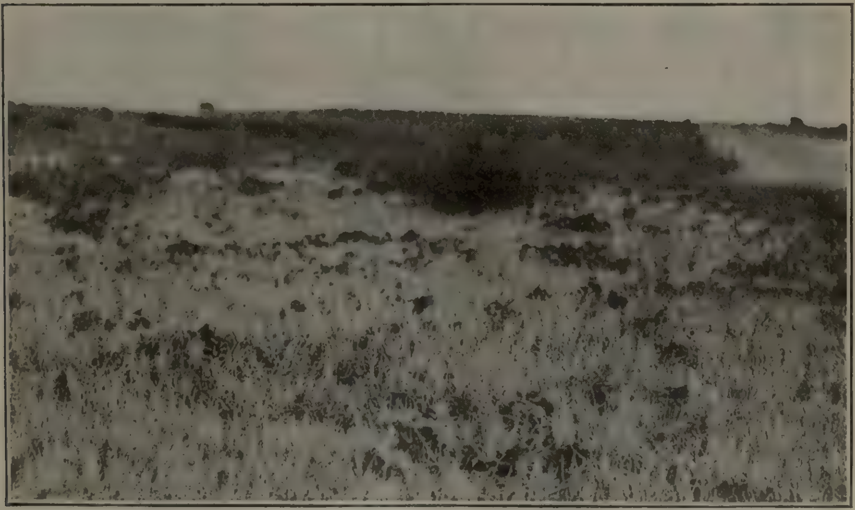
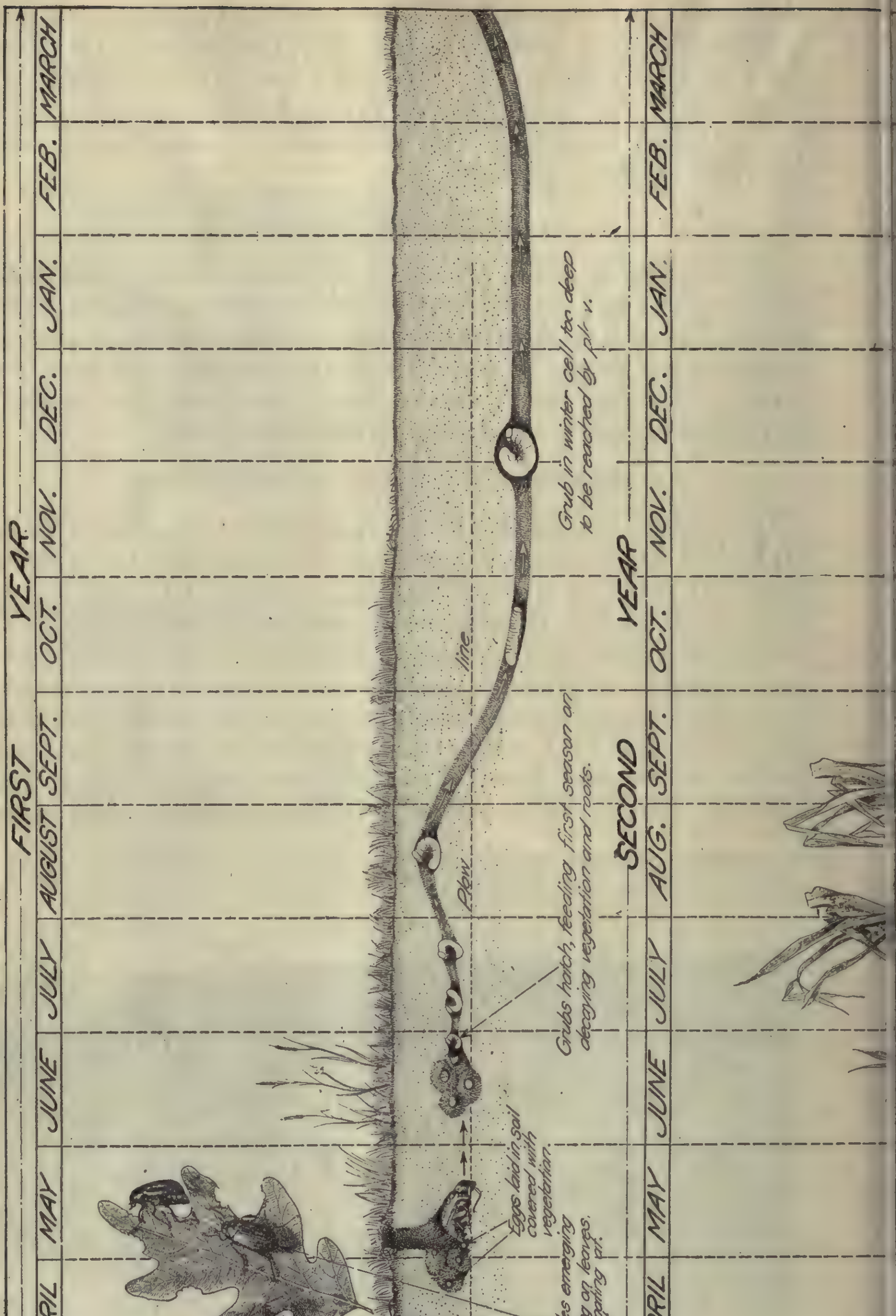


FIG. 16.—Timothy field after harvest, showing sod overturned by crows in their search for white grubs, Galena, Ill., 1912.


FIRST YEAR
APRIL
MAY
JUNE
JULY
AUGUST
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MARCH
Beetles emerging feeding on leaves, and mating at night
Eggs laid in soil covered with vegetation.
Grubs hatch, feeding first season on decaying vegetation and roots.
Plow line
Grub in winter cell too deep to be reached by plow.
SECOND YEAR
APRIL
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MARCH

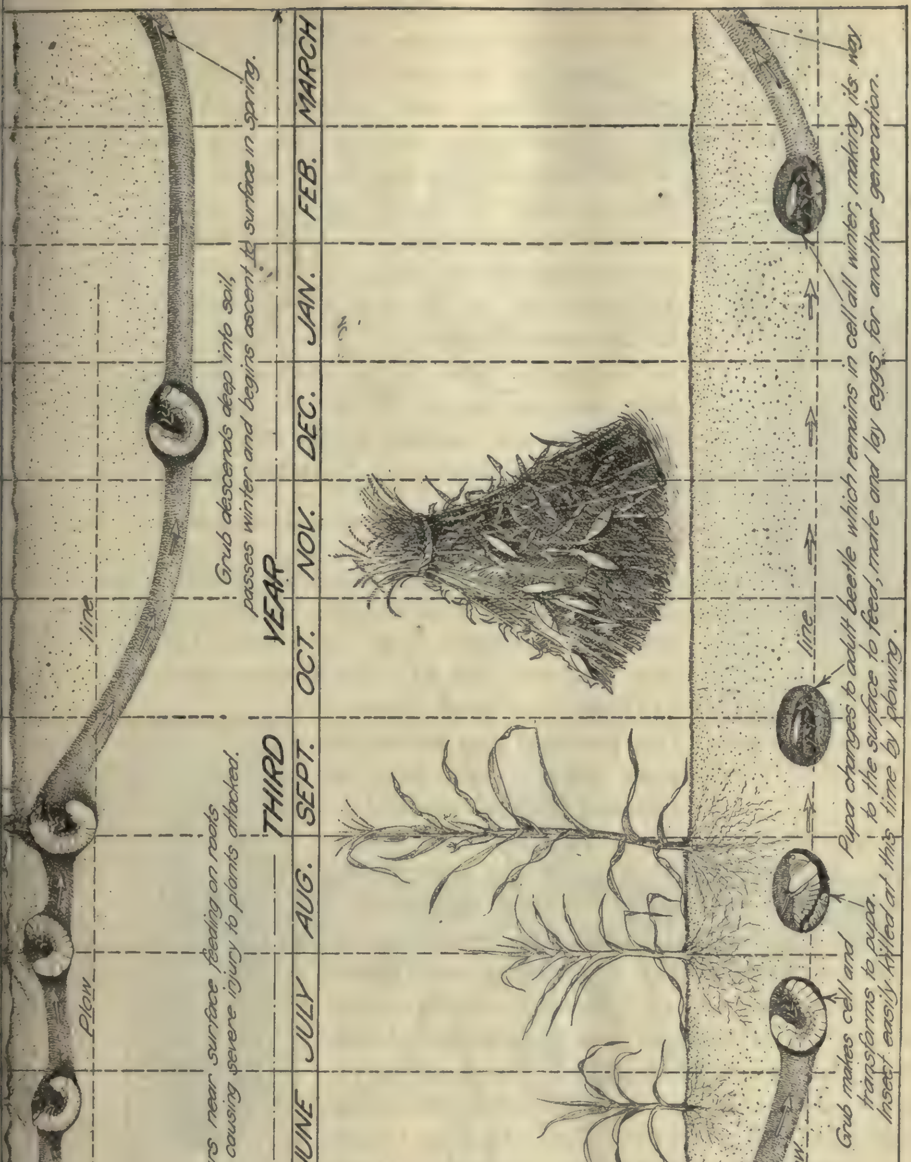

APRIL
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MARCH
THIRD YEAR
Plow line
Plow line
Grub reappears near surface feeding on roots of vegetation, causing severe injury to plants attacked.
Grub descends deep into soil; passes winter and begins ascent to surface in spring.
Grub reappears near surface and feeds.
Grub makes cell and transforms to pupa. Insect easily killed at this time by plowing.
Pupa changes to adult beetle which remains in cell all winter, making its way to the surface to feed, mate and lay eggs for another generation.

FIG. 14.—Diagram illustrating complete life cycle of white grubs, which covers a period of three years, and showing the periods during which they can be killed by plowing.

or cultivated, and then only in fields near the farm buildings, unless a portable poultry house, such as will be discussed later, is used.

The main objects to be gained by the practices indicated above are (1) eradication of grubs, cutworms, and probably such other insect pests as wireworms; (2) food value derived from the grubs, which is equal to a hog feed costing $25 to $35 per ton; (3) manuring the land. The United States Bureau of Animal Industry has estimated the value of manure to be $3.29 per ton in the case of hogs and $7.07 in the case of poultry.[1] When corn ground is "hogged" there is the additional advantage of a saving in labor and expense in harvesting and marketing the crop and the production of more pork from the crop.

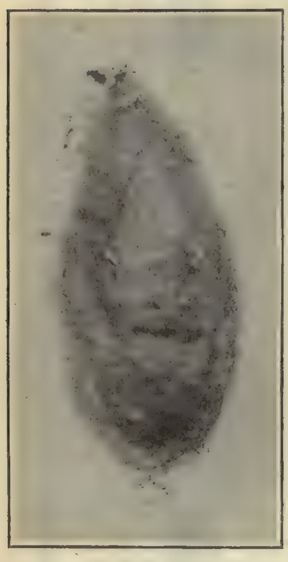


FIG. 17.—Cocoon of a wasp, *Tiphia* sp., a parasite of the larvæ of May beetles.

EXAMPLES OF INSECT CONTROL BY HOGS AND POULTRY.

The fondness of hogs for white grubs and May beetles is well known and evidenced wherever unringed hogs have been turned into pastures (fig. 21), but a most striking example has been shown.[2] One hundred pigs and eight sows were turned into an inclosed 10-acre cornfield at Ludlow, Ill., which was badly infested with grubs, September 23. Within 20 days 86 per cent of the grubs were destroyed and in 27 days less than 1 per cent of the original infestation remained—a benefit of over 99 per cent. If the number of grubs per hill is estimated as 34.6, the count made at the beginning of the experiment, and the number of hills of corn to the acre as 3,556 (hills 3⅓ feet each way), it is easily calculated that the pigs destroyed something like 1,217,083 grubs in 27 days; that is, 11,278 grubs, or possibly 24 pounds, per animal. These hogs, by the way, suffered no ill effects from the continuous ration of grubs.

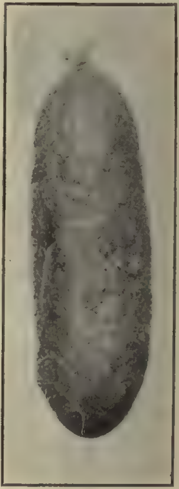


FIG. 18.—Cocoon of a wasp, *Elis* sp., a parasite of the larvæ of May beetles.

Turkeys are very fond of grubs and search diligently for them.

Poultry can be utilized to excellent advantage, especially if allowed the run of the fields during plowing or cultivation. The effective-

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[1] Weekly News Letter, U. S. Department of Agriculture, v. 4, no. 17, p. 3. November 29, 1916.

[2] Forbes, S. A. On the life history, habits, and economic relations of the white grubs and May beetles. Ill. Agr. Exp. Sta. Bul. 116, p. 478. August, 1907.

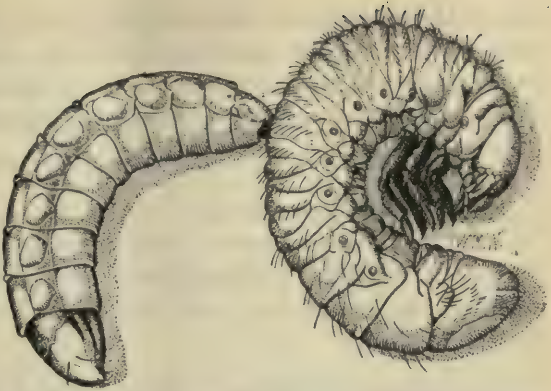

FIG. 19.—Larva of the robber-fly *Promachus vertebratus* attacking white grub.

ness of chickens in controlling white grubs is demonstrated by an experience at Froelich, Iowa, where the farm poultry, numbering about 150 chickens, were encouraged to follow the plow, harrow, and cultivator in a 15-acre field, badly infested with white grubs, adjoining the farm buildings. Scarcely a grub remained after a season's foraging by the chickens.

The value of portable poultry houses, which can be transferred from field to field or to any particular part of a field, has never been demonstrated in this country, but their use was advocated in Europe for the control of the European May-beetle grubs as early as 1860. The portable houses were described as having a capacity for 200 chickens, and being furnished with perches, numerous egg-laying compartments, and a box to catch the manure. The houses were moved to the field and each morning the chickens liberated to forage in the vicinity of their quarters. They returned to their coop toward evening and the door was closed, but the house was left in

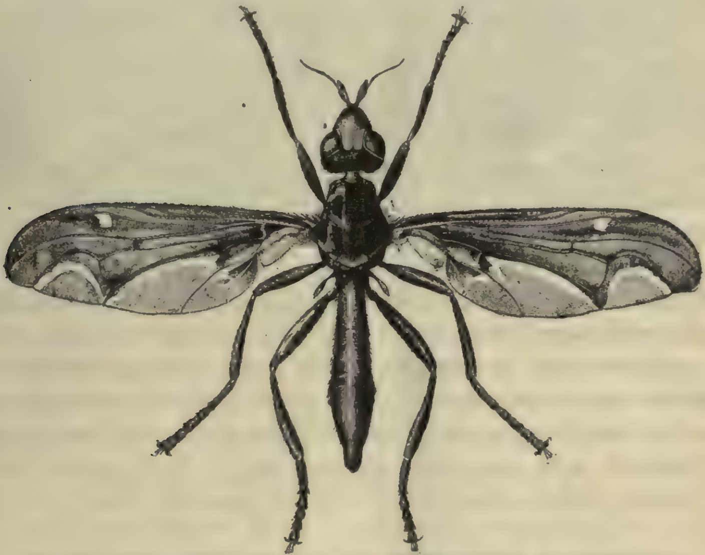

FIG. 20.—*Pyrgota undata*, a fly parasite of adult May beetles. Enlarged greatly.

the field continuously, except during the most severe winter nights. The advantages obtained, in addition to the destruction of grubs and other insects, were the utilization of a mass of grain left after harvest and the production and saving of the valuable manure.

VALUE OF WHITE GRUBS AND MAY BEETLES AS ANIMAL FOOD.

Through the cooperation of Mr. W. J. Jones, State Chemist of Indiana, standard chemical feeding analyses of white grubs and May beetles of the genus Lachnosterna have been made and these, together with an analysis of dent corn for comparison as given by Prof. W. A. Henry,[1] follows:

Analysis of dent corn, compared with white grubs and May beetles.

Material.	Grubs.[a]	Beetles.[b]	Corn.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	79.9	69.4	10.6
Crude fat	3.1	4.9	5.0
Crude protein	11.1	20.1	10.3
Crude fiber	1.6	3.7	2.2
Crude ash	2.0	1.6	1.5
Nitrogen-free extract (carbohydrates)	2.3	0.3	70.4

[a] One and two year old grubs collected behind plow in fall of 1916.
[b] Recently matured beetles collected behind plow in fall of 1916.

In comparison with such a standard feed as corn it will be noticed that in grubs the percentages of fat and protein, the most valuable foods in feeding material, about equal the percentages of these constituents in corn, while the percentages in beetles run much higher. The carbohydrates, on the other hand, are deficient in the insects; and this would indicate that the feeding of corn in connection with pasturing hogs in grub-infested land, or, better, "hogging down" corn if the infested field is in corn, is desirable and a good practice.

In the white-grub infested areas there is an average of 106,680 grubs per acre, and the weight of the grubs during the fall of their destructive season averages 1 gram each, that is, 454 to the pound, the beetles weighing slightly less. Thus it may be estimated that each infested acre contains approximately 235 pounds of grubs which have a value as hog food of more than $3, that is, $30 for ten acres.

VALUE OF WHITE GRUBS AND MAY BEETLES AS MANURE.

In addition to the value of grubs and May beetles as hog and poultry feed, the value of the manure produced should also be considered. As a general criterion the money value of hog manure has been estimated, as indicated above, at $3.29 and of poultry manure at $7.07 per ton. It is said[2] that during the life of the animal 85 per cent of the fertilizing constituents ingested by hogs as food is eliminated by the system in the urine and feces, the percentage being greater for mature individuals. By simplifying the protein constituents we find that the grubs contain 1.78 per cent nitrogen and the beetles 3.22 per cent, and since each heavily infested acre is estimated to contain 24 pounds of grubs or 16 pounds of May beetles we may figure that approximately 3½ pounds of nitrogen alone would be replaced in the manure produced by the hogs eating the grubs, and 4½ pounds if the food were in the form of beetles. The ash, constituting 2 per cent of the grubs and 1.6 per cent of the beetles, is heavy in phosphoric acid, but the exact amount of this and other fertilizing elements has not been ascertained.

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[1] Henry, W. A. Feeds and Feeding.

[2] Good, E. S. The growing and fattening of hogs in the dry lot and on forage crops. Ky. Agr. Exp. Sta. Bul. 175, p. 332. April, 1915. (Statement of Dr. H. S. Grindley quoted.)

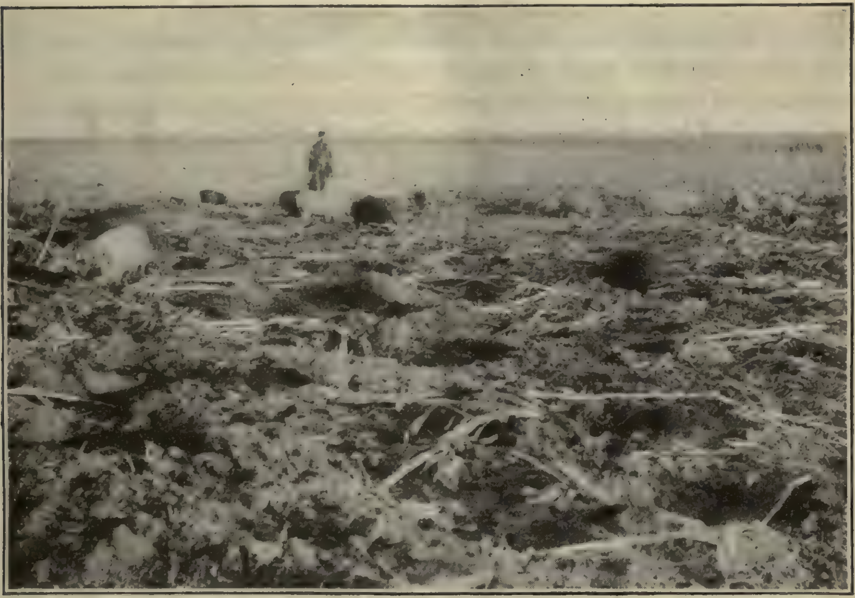

FIG. 21.—Hogs rooting for grubs in cornfield referred to on page 18. Photograph furnished by Dr. S. A. Forbes.

EFFECT RESULTING FROM CONTINUOUS GRUB DIET.

Occasionally reports of harmful effects to hogs from a continuous grub diet have been received, but it has not been possible to verify them. On the other hand, well-informed farmers and expert swine raisers who have had experience in pasturing hogs on grub-infested land disclaim any harmful or poisonous effects from such practices.

Likewise poultry may be fed white grubs and May beetles without any harmful results and without producing any noticeable effect in the eggs, such as is noticed when chickens feed continuously for several days on such caterpillars as the army worm. No difference in taste has been found in European tests between eggs from grubnourished hens and those from others. On the contrary, the eggs of the former had better yolks for thickening and were worth three of the others to color sauces. No unfavorable effects resulted from the use of either grubs or May beetles as chicken feed, except in the case of dried beetles mixed with bread or potatoes, which proved too exciting for the older fowls.

OBJECTIONS MADE TO GRUBS AS ANIMAL FOOD.

Three objections have been raised to the use of unringed hogs in grub-infested fields, most of which apply only in cases of pasturing on sod land. These objections are (1) lack of hog-tight fences; (2) rooting up of pasture land; (3) possible infestation with the giant thorn-headed worm,[1] an intestinal worm affecting hogs.

The first objection has been answered, for it has been shown that the value of the grubs as hog feed almost pays for the cost of fencing—at least temporary fencing.

Our observations show that an infested pasture, although overturned by rooting hogs, reseeds itself the following season with no ill effect other than a roughing of the surface, which is of little significance.

The last objection, relative to possible infestation with the giant thorn-headed worm, is of considerable importance. The white grub is one of the intermediate hosts of this worm, which seems capable of entering hogs only by being taken into the body with grubs eaten. No trouble will result from these worms, however, if hogs which have never been pastured are used in fields which have not been previously pastured with hogs within three years. Care should be taken to prevent brood sows from running in fields which are likely to contain grubs infested with thorn-headed worms, that is, in fields which have been hog-pastured the previous season or two, but hogs being fed for market can, with the possible exception of very young pigs, be pastured with less regard for the past history of the field, since they will be marketed before the effects of the worms, if any are present, become harmful.

SUGGESTIONS FOR THE USE OF HOGS FOR WHITE-GRUB CONTROL.

In the white-grub infested districts hogs may be used to advantage each year and in almost every season of the year. Figure 14 illustrates graphically the life cycle of this insect and should be used as a guide in pasturing hogs on infested ground. It should be noted that the grubs ordinarily go rather deep into the ground to pass the winter, usually starting their downward migration by October 10, so that it is desirable to practice fall pasturing previous to this date.

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[1] *Echinorhynchus gigas.*

During the flight of the beetles hogs should be pastured in timber lots or fields adjoining, that they may have an opportunity to destroy the beetles. In the fall of the year the beetles are abundant and the hogs should be pastured in small-grain stubble, timothy, bluegrass, or weedy lands, for here the beetles have laid their eggs and the young grubs are to be found. The year following an abundance of beetles, which is the year the grubs are most destructive, pasturing after the first of May is desirable when it can be done conveniently, but before this date the effect of pasturing on the grub population is not so evident, since the ground is usually quite hard and the grubs still in their winter quarters, often 2 feet or more below the surface. It has been shown that "hogging" corn is profitable and if the ground contains grubs it will be especially profitable for pasturing, since the combination of corn and grubs offers a fairly well-balanced ration. The third year, when the grubs mature and change to beetles, the hogs may be utilized at any season after May 1, and it is especially desirable to pasture them in ground which showed an abundance of grubs the preceding year.

As has already been inferred, poultry can be used to advantage at any time of the year, except possibly during the winter months when the grubs are deep in the ground, by permitting them to follow the plow, cultivator, and harrow whenever possible.

In pasturing hogs it is well to keep in mind the following points: (1) Accustom the hogs to corn and grubs gradually, especially the former; (2) a water supply should be considered; (3) it is best to fence off a single portion of the field at a time in order to make the eradication of grubs uniform and complete and to avoid waste in "hogging" corn; (4) a supply of salt should be available to the animals at all times.

ROTATION OF CROPS.

Rotations are especially important in avoiding white-grub injury. A rotation of oats or barley, clover, and corn has proved very satisfactory in some sections. Ground which is in corn or has a heavy stand of pure clover during the year the beetles are flying ordinarily will contain few grubs, since the beetles will not seek such land for laying their eggs, but prefer land in small grains or timothy, or covered with weeds. Land which is in oats, barley, or wheat during the flight of the beetles will contain many grubs, but if the grain is followed by clover, which is one of the least susceptible crops, the grubs will scarcely injure the clover. It is asserted that clover winter-kills badly in southern Wisconsin, northern Illinois, and similar latitudes. but there is reason to believe that this is because the clover is not sufficiently vigorous to survive severe winters, and the remedy is liming or otherwise treating the land so as to grow a vigorous stand of clover. Aside from this rotation, it is desirable to arrange the crops so that the least amount of land will be in timothy and small grain the year the beetles are abundant, and the following year to plant corn on corn ground, and use for small grain and timothy the ground which was in these crops the previous year. Where hogs can be pastured on the land the fall previous to planting, as under the conditions discussed in the preceding paragraphs, less regard need be had to the selection of crops, since a thorough pasturing by hogs will practically eradicate the grubs.

FALL PLOWING.

Where it is impractical to pasture hogs in an infested field or to follow the prescribed methods of rotation, some good can be accomplished by plowing the ground in the fall. Fall plowing previous to the time the grubs go deep into the ground to pass the winter, i. e., previous to October 10, as a rule will destroy many of the grubs and should be practiced whenever possible but should not be considered a panacea for the grubs. Ordinarily the best time to plow with this object in view is between October 1 and October 10. The main point to be remembered is to plow before the grubs go below the plow line and as short a time before this as can be done.

Summer and fall plowing the year the grubs are changing to beetles, that is, in 1918 for brood C and in 1919 for brood A, is of special value, and every piece of ground which contained grubs in their injurious stage the previous year should be plowed, if at all possible, as soon after July 15 as is practicable, and the sooner this is done after that date the more thoroughly will the pests be eliminated. A plow which will *break up the soil* as it is overturned should be used, or if this is not possible the ground should be deeply disked after plowing in order to break up the soil and disturb the insects in it. Whenever a grub-infested field is being plowed, harrowed, or cultivated where chickens are available, these should have the run of the field.

COLLECTING THE GRUBS AND BEETLES.

Where it is possible to secure cheap labor, collecting the grubs after the plow is practicable, especially where the grubs are numerous. In Europe children are often employed to gather grubs in this manner and to collect the beetles.

Collecting the cockchafer,[1] a beetle very closely related to the May beetle, is a common practice in European countries, but so far as known no attempt to collect May beetles on an extensive scale in the United States has ever been made. Three methods may be employed in beetle destruction: (1) Collecting from plants upon which they feed at night, (2) trapping at lights, and (3) poisoning their food plants.

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[1] *Melolontha vulgaris* Linnaeus.

In Europe beetle collecting has proved of value largely because the years of abundance of the beetles have been definitely known in advance, while in America this has not been the case. Now, however, there is proof that the beetles occurring in such abundance in many parts of the United States in 1914 (the parents of the destructive generation of grubs in 1915) have a life cycle of three years, and it is reasonably certain that they will continue to be exceptionally abundant in these regions every three years unless killed off by their natural enemies, by artificial means, or by unfavorable climatic conditions. Beetle collecting in the Old World has also proved practicable, first, because of the organized cooperative movement among the farmers for the collection of the beetles; second, because a small bounty is paid for the beetles; and, third, because of laws which in some countries require each farmer to collect a certain quantity of the grubs or beetles each year. Only where whole communities or neighborhoods cooperate in the work is it effective.

In collecting from food plants large cloth sheets are placed under the tree and the latter jarred, or in the case of large trees individual branches may be shaken by using a long pole provided with a hook at the end. The beetles are then gathered up from the sheet and placed in cans, bottles, or boxes and afterwards killed with the vapor of carbon disulphid. Killed in this manner they may be fed to chickens, pigs, etc., but if they are not to be used for such purposes they may be killed by dropping them in cans containing water and just enough kerosene oil to cover the surface. As a rule beetles are most abundant on the oak, walnut, poplar, hackberry, willow, ash, and elm. Collections may be made at any time during the night, but the best time for this work is in the early morning, before 4.30 o'clock, at a time when the beetles are easily jarred from the foliage. It is essential that collecting be begun as soon as the beetles appear in the spring—that is, before the beetles have begun to lay their eggs—and it should also be borne in mind that each female beetle destroyed early in the season means the destruction of from 50 to 100 grubs which she might have produced.

Light traps have not as yet proved satisfactory as a means of control against May beetles, the prime objection to this method being that the light attracts the males to the almost total exclusion of the females. Further tests with this method must be made, and it is possible that the light may prove attractive to the female beetles in years of unusual abundance if placed close to the trees or shrubs upon which they feed.

SPRAYING.

Spraying trees upon which the beetles feed, with Paris green, arsenate of lead, or similar arsenical, is effective against the beetles, but ordinarily this method is impracticable owing to the large size of the trees, which would necessitate large and expensive power sprayers. After more definite knowledge of the preferred food plants has been obtained it may be found practicable in some localities to plant low-growing trees and shrubs about fields as traps for the beetles, which might then be destroyed by spraying.

SPECIAL DIRECTIONS.

In those regions in which the grubs were abundant and destructive in known years certain special directions and precautions may prevent a repetition of damage. As has already been stated, the parents of the grubs of 1915 appeared in the spring of 1914 and laid the eggs which hatched into grubs. Practically no damage occurred that year, but in 1915, when about half grown, the grubs caused great loss. These grubs continued active in the spring of 1916 and injured certain early plantings, but by early June most of the grubs became more or less inactive and later changed to the dormant or pupa stage, transforming into beetles about August. They remained in the soil as beetles over winter, appearing above ground in the spring of 1917.

The accompanying table (p. 28) will assist in preventing grub injury, especially in those localities (see figs. 7 and 8, p. 8) where the grubs make their appearance regularly each third year.

IN THE LAWN.

Lawns destroyed by grubs should be resodded or reseeded, the old sod being first removed and the grubs gathered by hand, although if poultry, especially turkeys, are allowed the run of the ground as the old sod is being removed, they will do the work in a thorough manner. If the infestation is slight, liberal applications of a commercial fertilizer will assist the grass in overcoming the grub injury. Experiments in Europe with a European white grub have demonstrated that carbon disulphid injected into the soil at a depth not exceeding 6 inches, at the rate of 1 to 1½ ounces in six or eight holes per square yard, will considerably diminish the number of grubs. It appears very probable that this method would prove satisfactory for our white grubs when they appear in lawns. In fact, the experience of the department indicates that carbon disulphid can be used with profitable results. Care should be taken not to water the treated ground for 24 hours after application, since a saturated soil prevents the disulphid from evaporating, thus making it less effective and rendering the grass roots liable to injury. *In using carbon disulphid care should be exercised never to permit a spark of fire to come near it, for it is extremely inflammable, and its vapor mixed with air in certain proportions is* *explosive.* Holes in which the carbon disulphid is injected should be closed with a plug of soil or sod immediately after the injection, to prevent the escape of the fumes.

Kerosene emulsion has been recommended repeatedly as an effective grub insecticide. The department's tests indicate that it is satisfactory against grubs if thoroughly applied when the grubs are near the surface and the emulsion then washed well into the soil by copious sprinkling. Watering washes the emulsion from the grass and prevents burning and at the same time permits the insecticide to penetrate more thoroughly into the soil. For small areas an ordinary sprinkling can may be used in applying the emulsion, but for larger areas the use of a force pump will save time and labor, a wide sprinkling can type of nozzle or "rose" being used, so that the lawn can be uniformly drenched in the shortest possible time.

Kerosene emulsion is prepared as follows: One-half pound of hard soap or 1 quart of soft soap, preferably fish-oil, rosin-soda, or rosin-potash soap, is dissolved in 1 gallon of boiling water, and while hot 2 gallons of kerosene are added and the mixture thoroughly emulsified. This may be done most easily and thoroughly by churning for about 10 minutes with a spray-pump, the nozzle being turned back into the liquid. When thoroughly emulsified the preparation will have the consistency of thick cream, and the oil will not separate. Danger of injuring plants is great if the mixture is not well and thoroughly made. For a 7½ per cent emulsion add 25 gallons of water to the above stock solution and mix thoroughly. It is desirable to use soft water both for the stock and for diluting, but where this is not obtainable the water should be softened by adding lye or sal-soda. A much better emulsion, apparently more effective and more easily made, is prepared by the use of fusel oil. It is prepared by dissolving 3½ pounds of fish-oil soap in enough water to make a gallon, adding 1 quart of fusel oil and then 2 gallons of kerosene. When this is churned thoroughly and emulsified, add 25 gallons of water, to make approximately a 7½ per cent emulsion.

It might be mentioned here that carbon disulphid may be injected with excellent results into the holes of the grub of the southern green June beetle, which is frequently quite injurious to lawns and golf greens in the Southern States. Kerosene emulsion likewise has given excellent results against this grub.

TABLE SHOWING WHAT TO DO AT EACH STAGE OF THE WHITE GRUB.

WHEN TO BE EXPECTED.	WHAT TO DO.
(1) Heavy Flights of May Beetles.	
Brood A: Previous heavy flight was in 1917; the next heavy flight can be expected in May, 1920. Brood C: Previous heavy flight in 1916; the next heavy flight can be expected in May, 1919.	Use lantern traps during beetles' flights. Spray trees with an arsenical, such as Paris green or arsenate of lead, to destroy beetles feeding thereon. Plow grass and small grain land previous to October 1, to destroy young grubs recently hatched from eggs laid by May beetles.
(2) Small Grubs Abundant in the Fall.	
Brood A: Small grubs were last abundant in the fall of 1917 and are to be expected in the fall of 1920. Brood C: Small grubs were last abundant in the fall of 1916 and are to be expected in the fall of 1919.	Plow thoroughly previous to October 1. Seed such land to small grain or clover for the following year. Do not plant corn or potatoes on such land the following season. Pasture hogs and allow chickens to run the fields when cultivated.
(3) Small Grubs Abundant in the Spring.	
Small grubs abundant in the spring indicate heavy damage during the coming summer, as these small grubs are the holdovers from the eggs laid the previous year and will be large enough to become very destructive to live roots.	Seed such land to small grain or clover. Do not plant corn or wide-row crop in such land. Put corn, potatoes, field beans, etc., on ground clean-cultivated the preceding year. Pasture hogs on infested ground.
Brood A, destructive in 1918; Brood C, destructive in 1917.	1918 for Brood A; 1919 for Brood C.
(4) Large Grubs Abundant in the Fall or Spring.	
Brood A: Fall of 1918; spring of 1919. Brood C: Fall of 1917; spring of 1918. Large grubs in the fall or spring indicate that the grub is about to go into the pupa stage and start its new 3-year cycle. These large grubs may be expected to do some damage, but by the middle of June they become dormant and begin to pass into the pupa and underground beetle stages.	Plow infested land about October 1 in fall of 1918 for Brood A and in fall of 1920 for Brood C. Delay planting until 15th or 20th of May, or a little later if practicable. Ground with large grubs in spring should be plowed as soon after July 15 as practicable, as indicated below. Pasture with hogs when possible.
(5) Beetles or Pupæ in the Ground in Summer.	
These should be found in the summer of 1919 for Brood A and in the summer of 1918 for Brood C. May be expected in all ground containing large grubs or where damage occurred the previous season.	Pasture with hogs where possible. Plow thoroughly, so as to break the clods, any time after July 15; the sooner after that date the better. 1919 for Brood A; 1918 for Brood C.

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WATER SYSTEMS FOR FARM HOMES

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FARMERS' BULLETIN 941

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Public Roads
LOGAN WALLER PAGE, Director

Washington, D. C. October, 1918

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A WATER SYSTEM that will provide a wholesome supply for family use, prove serviceable for farm uses, be as nearly permanent as may be made, and cost the least has been one of the four principal utility problems of the average farmer. The aim of this bulletin is to give to farmers, county agents, and others basic information concerning sanitary and engineering principles underlying safe, serviceable, and lasting water systems for farmhouses.

WATER SYSTEMS FOR FARM HOMES.

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INTRODUCTION.

A GOOD WATER SUPPLY, a complete sewage-disposal plant, and effective heating and lighting systems constitute the four prime utilities of the farm home, the foundations of safe, comfortable living. To secure these ends in greatest measure, thought and planning are necessary. If the procedure is haphazard, if the parts are not correlated, there is neither economy in the construction nor satisfaction in the operation of the plant. To illustrate: When locating the well, the direction of surface and underground drainage should be considered, to the end that the water supply may not be contaminated by the sink drain, cesspool, or other sources of filth. The unused water from a spring or flowing well may be made valuable if brought to a watering trough, cooling tank, fish pond, or swimming pool, or harvested as ice. A saving may be effected by laying two lines of pipe in one trench. The engine which drives the pump may operate other useful appliances, such as a dynamo, saw, washing machine, cream separator, or churn. Figure 1 suggests a utility room built as an addition to a farmhouse having few improvements and no cellar. Attention is directed to the convenience of a laundry and a lavatory and a warm, dry room just off the main part of the house where farm hands can wash, and in stormy weather deposit their wet coats, boots, and shoes. A notable example of home-planned utilities is found upon a farm in northern Utah. By personal planning and hard work, the owner of this farm gradually has equipped his house with a pressure water system, a laundry containing a power washing machine, wringer, mangle, and drying machine, a heating plant, electric lights, electric range, electric heaters for emergency use in chambers, and a vacuum cleaning system.

SANITARY ASPECT OF FARM WATER SUPPLY.

Observation indicates that on the average three out of four farm wells are located within 75 feet of the back door of the house and in the direction of the barn. That convenience and first cost—not safety—have been the deciding factors in thousands of such locations is a fact made evident by the proximity of barnyards, pig pens, pastures, fertilized fields, sink drains, privies, cesspools, and house yards rendered insanitary by chickens, slops, garbage, and other filth. Too frequently the leach from these or other sources of filth, after joining the ground water, moves with greater or less directness to wells and springs, seriously impairing the water supply by organic impurity or grossly poisoning it with human sewage.

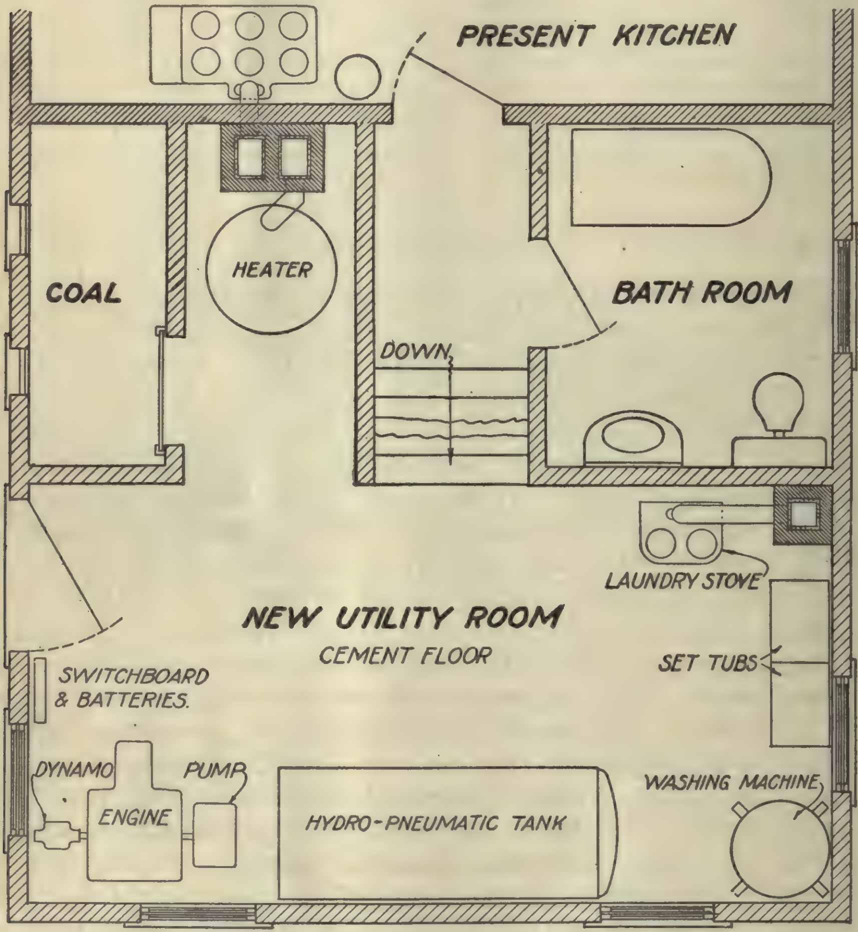

FIG. 1.—Suggested utility room for a farmhouse having few improvements and no cellar.

Among other ways by which surface waters and open or poorly covered wells and springs are contaminated or receive noxious substances are: Surface wash from roads, ranges, or the other sources of filth above mentioned; bodily entry of stock and poultry or their droppings; filth from the shoes of careless farm hands and children; drippings from the dipper or bucket handled by carriers of disease; dust and leaves from the air; and entry of worms, bugs, spiders, toads, frogs, mice, snakes, cats, or other animal life, which through death and decomposition may impart to the water disagreeable odor and taste and perhaps more serious characteristics.

Deterioration of water may be due to still other causes that make it unwholesome but not, so far as known, destructive of health. Among such are unusual dissolving of mineral salts from the earth, washings from clay that produce a milky appearance, discoloration from mineral or vegetable matter, admixture of mineral or vegetable oils, absorption of offensive gases, low forms of animal life, minute plant growths often productive of bright-colored, fibrous masses and scums, and, especially when water is of peaty or swampy origin, impregnation with iron. In short, investigations indicate that only a small minority of farm water supplies can be classed as unqualifiedly safe and desirable.

A few examples are cited herewith:

In September, 1900, water collected at a spring in Plymouth County, Mass., contained 2,650 bacteria per cubic centimeter (about 15 drops), including one species which normally infests the intestines of man and warm-blooded animals. The watershed contained cultivated fields and 10 houses with outbuildings, the nearest of which was within 300 feet of the spring. The spring was in a cemented reservoir 3 feet deep, resting on a ledge and covered with a platform, but not protected from surface water.[1]

In August, 1900, water as bottled for sale from a spring in Middlesex County, Mass., contained 483,000 bacteria per cubic centimeter, including one species normally of fecal origin. The watershed was chiefly cultivated and pasture land, and no house was within one-half mile of the spring, which was in a cemented reservoir 15 feet in diameter and 15 feet deep, resting on rock, and closed with an iron cover. From the spring the water flowed through 1,560 feet of tin-lined lead pipe to the bottling house.[1]

In July, 1911, the water of a nicely located and apparently tightly covered dug well at Highland Springs, Va., became foul smelling and tasting. Inspection disclosed 16 live frogs and 6 more or less decomposed.

In August, 1915, in Campbell County, Va., a quantity of dilute sewage trickled into a drilled well from the well pit above, the latter having become flooded from a house sewer choked with rain water. Within 14 days five of the eight children in the family were stricken with typhoid fever and the eldest died three weeks later.[2]

On February 5, 1916, a mountain spring supplying a farm used for educational purposes in Idaho and which was inclosed by a concrete box with tight plank cover was, upon inspection, found to have had the cover crushed in by cattle and the site thickly strewn with droppings. As the locality was covered with snow and the spring water comparatively warm (66° F.), it may be concluded that unusual effort had been made by stock to reach the water at its source.

Among the ailments caused or influenced by contaminated water are typhoid fever, tuberculosis, hookworm disease, cholera, dysentery and diarrhea, and certain obscure maladies that may be traced eventually to the poisonous effects of drainage from human wastes. Figure 2 shows in a striking manner how increased use of pure water in Massachusetts has been followed by decline in the typhoid-fever death rate. Frequently a home or village supplied with water from a mountain spring or canon is a center of goiter, although the possible relationship of such water to this disease has not been proved conclusively.

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[1] Condensed from Annual Report, Mass. State Board of Health for 1900, pp. 561, 563, 580, and 583.

[2] Condensed from Annual Report of Health Commissioner, Va., 1915, p. 98.

Among ailments of live stock, hog cholera, anthrax, and foot-and-mouth disease are spread by moving water. Hence sick animals should not have access to streams, and dead animals should not be left exposed in fields or buried where drainage may carry infection to streams and water supplies. One's duty to himself and neighbors should obligate him to confine all sick animals and burn the carcasses of dead ones or bury them deeply in spots remote from streams, wells, and springs, and urge his neighbor to do the same.

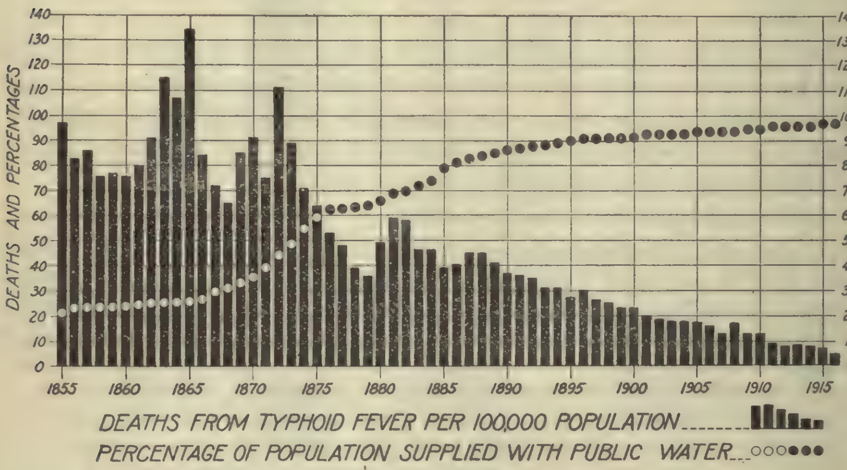

FIG. 2.—Typhoid-fever death rate and percentage of the population supplied with public water in the State of Massachusetts from 1855 to 1916. Notice the rise of the circles and the drop of the black bars. In 1916 fully 96 per cent of the people were supplied with public water and the typhoid-fever death rate declined to 4.6 per 100,000 population. Unquestionably pure water was the chief factor contributing to this notable decline.

DISPOSITION AND MOVEMENT OF WATER.

Rain is the source of water supply, and whether in the air or upon or within the ground, water is always acted upon by the earth's gravity. A part of the rainfall is reevaporated, a part is taken up by vegetation, and other portions run away over the surface of the ground or sink downward and percolate through the ground. Surface run-off and percolating water (ground water) both move in the lines of least resistance (lines of greatest slope and least obstruction) toward lower levels, dissolving more or less of the mineral and organic constituents of the earth over or through which they pass. Steep slopes and close soils increase the proportion of surface run-off, and flat slopes and open soils increase the porportion of ground water. In all cases increased slope means greater velocity. Close soils mean slower velocity of the ground water, the movement being not unlike that of ink in a piece of blotting paper. Ground water may move at rates of much less than a rod per day many miles through earth, or may enter the underlying rock and move freely through its crevices or very slowly through its pores. Due to peculiarities of the earth's slope and structure, it may appear at the surface as a seep or spring or enter a lake or a stream channel. The deeper and the longer either in distance or time the underground journey is, the greater the liability of mineral impregnation, but the less the chance of organic impurity.[1]

The vital things to remember are that ground water is not stagnant but moves usually, though not always, with the ''lay'' or slope of the land; that its character determines largely the character of wells and springs; that it is not an inexhaustible reservoir, but that a given well yields only as it receives; and that continued pumping will not improve the water in a well if the sources from which it is fed are permanently at fault. In short, ground water is natural drainage variously modified in its movement and character by subterranean conditions.

SAFE LOCATION OF WELLS.

Wells can not be located in all cases so that there may not be some pollution, but the great safeguards are clean ground and as wide separation as possible from the probable channels of any impure drainage. It is not enough that a well or spring is 50, 100, or 150 feet from a source of filth or that it is merely upon higher ground, although even moderate remoteness and elevation of the source of supply are of service. Given porous or gravelly ground, seamy ledge, or long-continued pollution of one plot of land, the zone of contamination is likely to extend long distances, particularly in downhill directions and at such times as water supplies are lowered by drought or heavy pumping. Only when the surface of the water in a well or spring is actually at a higher level at all times than any near-by source of filth is there positive assurance of safety.

Upon any farm a wood lot, grove, or windbreak is highly desirable, not only to supply fuel and small timber, but for its beauty and the protection it affords. If kept clean and free from stock, such wooded area, an orchard even, may be made to serve another useful purpose, that of supplying water. Forest-covered lands conserve rainfall and soil moisture and in many instances afford ideal sources for farm water supplies. The farmer, therefore, who fences off his wood lot, or part of it, or forests an inclosed area and keeps it clean for water supply purposes, is following closely the wise policy of cities and towns which, to insure safe, ample water supplies, acquire elevated, sparsely-settled watersheds, and clean, forest, and patrol them.

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[1] Out of 1,943 wells less than 25 feet deep in Illinois 74 per cent were condemned; out of 2,707 wells 25 to 50 feet deep 63 per cent were condemned; out of 1,333 wells 50 to 100 feet deep 32 per cent were condemned; out of 3,228 wells more than 100 feet deep only 13 per cent were condemned. See "Water Survey Series, No. 13," Edward Bartow, Director, Urbana, Ill., p. 15.

Figure 3 illustrates a common, but unsafe, location for a farm well and a spring liable to contamination from both upland drainage and flooding in the stream. Beyond the probable channels of impure drainage is a wooded area which might afford an ideal and lasting source of good water supply.

CHARACTERISTICS AND TESTS.

Water for domestic use should be clear, lustrous, odorless, colorless, wholesome, soft, neither strongly acid nor alkaline, and its temperature for general farm purposes should be about 50° F. These characteristics, however, must never be deemed proof of purity, for a glass of water may possess them all and yet contain millions of disease-producing germs. Any suspicious water should be rejected until both the water and the surroundings where it is obtained are passed upon by competent sanitation authority, generally the State board of health.

There are few tests for contamination that the farmer can make. Peculiar odors, those of earthy, musty, vegetable, sulphurous, fishy, or fecal character, sometimes are developed by shaking or by heat. Water may be tinted green by vegetation or other shades by wash from clays. Brown and yellow tints are indicative of organic impurity and should be regarded with suspicion. Organic matter is indicated sometimes by the following simple test: Add a very little clean, white, granulated sugar to a half pint of the water in a clear, stoppered bottle, and allow it to stand in a warm room for a few days or a week. Gradually increasing turbidity, a smoky clouding, is evidence of impurity. Organic matter in water may be indicated also by heating any deposited sediment in a small porcelain dish over an alcohol flame and noting if the deposit chars and blackens.

The temperature of ground water varies with latitude, season, depth, and geological conditions. Ordinarily, at a depth of 40 to 60 feet, it is about 50° and is nearly uniform throughout the year. At lesser depth, seasonal and atmospheric changes are likely to affect it. Hence, if there is much fluctuation in the temperature, or if the water is made turbid by rains, a supply of shallow origin is indicated.

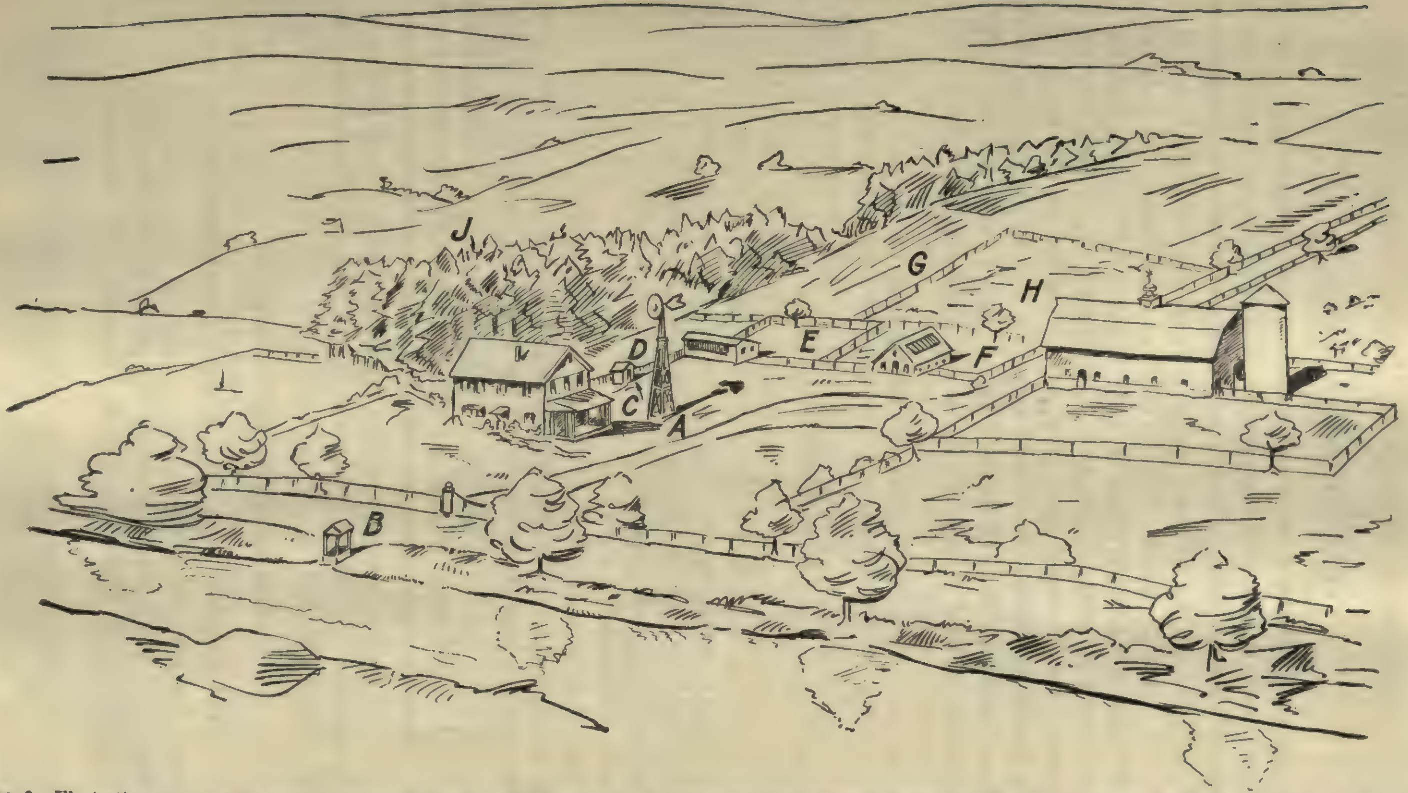

FIG. 3.—Illustrating common but unsafe location of the farm well and spring. A possible source of pure water is indicated also. *A*, Unsafe well; *B*, unsafe spring; *C*, privy; *D*, garden; *E*, chicken yard; *F*, hog yard; *G*, cultivated field; *H*, pasture; *J*, woodlot fenced off and kept clean; here, beyond the probable channels of impure drainage may be pure water.

Deep ground waters are generally progressively warmer, the deeper obtained, the increase running about 1° for each 50 to 60 feet increase in depth.

CONSUMPTION OF WATER.

The principal factors affecting water consumption are accessibility, pressure, quality and quantity of the supply, varying daily and seasonal needs, and personal differences of taste and habit. If carried by hand a long distance water will be used sparingly, perhaps one or two buckets drawn before mealtime sufficing for a family. If delivered under pressure and of good quality and ample quantity, it will be used liberally. Large quantities are used on wash days, during very hot weather, and, if water is wasted at the faucets to prevent freezing, during very cold weather. A bath requires 25 to 30 gallons, and each flush of a toilet takes from 3½ to 6 gallons. Fair requirements in rural homes are shown in the following table:

Water requirements in rural homes.

Purposes and conditions.	Consumption per person for 24 hours.
	Gallons.
Domestic purposes, 1 pump at kitchen sink	8
Domestic purposes, 1 faucet at kitchen sink	15
Domestic purposes, running hot and cold water in kitchen, bathroom, and laundry	25
Sprinkling and cooling purposes, outdoor washing, waste, leakage, etc	15
Average daily consumption, modern home	40
Maximum daily consumption, modern home	100
Average daytime consumption (7 a. m. to 7 p. m.)	28

As to the requirements of stock, animals prefer a living spring or a stream of pure cool water, and will go a long distance to obtain it. If supplied from artificial sources, fair allowances are 12 gallons per day for each horse, mule, or cow, and 2 gallons per day for each sheep or hog. Heavily worked horses and mules and milch cows may consume 20 to 25 gallons per day in hot weather, and with all farm animals conditions of weather, food, and living may double or halve the ordinary requirements.

WATER SUPPLIES CLASSIFIED.

Farm water supplies may be classified according to the source from which derived as follows:

(1) Rain and snow water (barrel and cistern storage).

(2) Surface water (streams, ponds, irrigation ditches, open reservoirs).

(3) Ground water (seeps, springs, dug and tubular wells, infiltration cribs and galleries, and collecting conduits).

RAIN WATER.

Rain water is soft and comparatively pure but contains ammonia, acids, dust, and other impurities washed from the atmosphere. On account of its softness and solvent powers it is used widely for laundry and general washing purposes, and in many sections where the ground-water supply is very deep, lacking in quantity, or strongly alkaline, rain water is the main reliance for all household uses.

CISTERNS.

Cisterns are wooden, metallic, plastered-on-earth, or masonry receptacles for the storage of rain water or melted snow. The evils of cistern water are many. They relate to the uncertainty of rainfall; to freezing in winter and unwholesomeness in summer; to impregnation with iron, zinc, or other metal in metal-lined cisterns; to direct entrance of organic matter in the form of dust, dirt, soot, insects, bird droppings, and even the bodies of birds and mice from roofs and conductors; to disagreeable tastes on account of the solubility of some roofing materials; to metallic taste acquired from the lime or cement in cistern walls; to the development of fungous growth and the organisms of decay as effects of long storage; to the entrance of roots of trees; to neglect in caring and cleaning; and, finally, to faulty construction or the development of leaks which permit either surface wash or underground leachings from sink drains, privies, cesspools, or other sources of filth to enter, harden, and contaminate the supply. A single example of cistern-water pollution is cited here:

In September, 1908, cistern water at a large farm in Kittson County, Minn., was found to be badly polluted, containing 80,000 bacteria per cubic centimeter (about 15 drops), including one species normally of fecal origin. The water was stored in two 100-gallon, uncovered, round, galvanized iron cisterns in the house cellar and was dipped out with pails for drinking and household purposes. A tin pipe leading from the roof to the cisterns was provided with a very small filter consisting of a tin box 12 inches by 5 inches by 5 inches filled with a clean bag of charcoal after each rain.[1]

The practice of throwing charcoal into cisterns to absorb the odors of decaying organic matter is of little advantage. Boiling cistern water, or "dosing" it with chemicals to sterilize it, although safe precautions, injure the wholesomeness of the water and should be regarded as emergency measures, never as suitable substitutes for the best possible construction and operation.

Notwithstanding the serious objections mentioned, thoroughly well-constructed, well-operated cistern installations are a boon, and their more extensive use is advised and urged. The vital features of a cistern installation are:

1. Absolute water tightness, top, sides, and bottom, and close screening of inlet and waste pipes.

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[1] U. S. Department of Agriculture, Bureau of Animal Industry, Bulletin 154, pp. 66, 79.

2. Provision for excluding from the cistern the first portion of each rainfall until the roof or other collecting area has become rinsed thoroughly.
3. A first-class filter of clean, well-selected sand and thoroughly burned charcoal. The flow should be downward, and the top area of the filter bed and the rate of flow to the bed must be so harmonized and regulated that slow, effective filtration (not rapid straining) is secured.
4. A waste pipe which removes surplus inflow from the bottom of the cistern where impurities tend naturally to settle.
5. Periodic and thorough cleaning of the cistern and filter. From time to time the clogged sand should be raked or renewed and the dirty charcoal replaced.

Other important features are:

1. Substantial construction of concrete plastered with rich Portland-cement mortar worked with trowels while green to produce a hard, impervious surface.[1] Lead-lined cisterns never should be used, and copper cisterns should be heavily tinned. Iron and steel cisterns should be well covered with pure asphalt paint; at greater cost they may be lined with tin or faced with slate, glass brick, porcelain brick, or tile. New cisterns should be pumped out two or three times prior to use of the water for drinking.
2. If water-tight, a cistern should be below ground, thus preventing freezing in winter and adding to the wholesomeness of the water in summer. The filter should be placed so the water in it can be drained away. This may require it to be above or partially above the ground.
3. If rain water is filtered effectively, the keeping qualities will be improved greatly and large-sized cisterns may be used. When a cistern is full, deflect and waste any flow from the roof, thus avoiding unnecessary work on the filter.
4. Never connect the waste pipe with a sewer or a drain which may carry sewage. The practice is dangerous. (See example 4, p. 5.)

The proper size of a cistern depends on the requirements for water, the area of roof or roofs, and the amount and frequency of rainfall. A liberal margin (perhaps one-third of the rainfall) should be allowed for the rinsings wasted, the water blown from the roof by wind, leakage in conductors and connections, and evaporation. Data (past records) of the amount and the seasonal distribution of rainfall at the principal cities throughout the country may be obtained from the United States Weather Bureau, Washington, D. C., from local forecasters in the several States, and from published reports of the Weather Bureau in many libraries.

To determine the amount of water falling on roofs: Measure horizontally in feet the ground plan of the roof and compute the area of the ground plan in square feet. Multiply this area by the rainfall in inches (for the wet-weather period which must supply the desired storage) and divide the product by 1.6. The result will be the number of gallons which may be expected from past rainfall records. The table on page 14 shows the capacities, both in gallons and barrels, of cylindrical cisterns and tanks of certain dimensions.

To find the capacity of square or rectangular cisterns and tanks: Multiply the inside length by the breadth and the product by the height, each dimension being in feet. Multiply the result (cubic feet) by 7½ to find the gallons. Gallons divided by 31½ give barrels.

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[1] For methods of mixing and placing concrete and mortar to promote imperviousness and resistance to the action of alkaline water, see Department of Agriculture Bulletin 230, "Oil-Mixed Portland Cement Concrete."

An example is given to show how, under fixed conditions, the dimensions of a cistern may be determined roughly:

A farm in Texas has a mean annual rainfall of 15.15 inches, of which 11.95 inches fall May to October, inclusive, and only 3.20 inches November to April, inclusive. Each person in a family of 5 requires 5 gallons of water daily, the roof plan measures 30 feet by 50 feet, and one-third of each rain is wasted because of dust and dirt on the roof. Obviously, the surplus May to October, inclusive, must be stored to meet the deficiency from November to April, inclusive. The area of the roof plan is $30\times50=1,500$ square feet. Applying the rule given, $\frac{1,500\times11.95}{1.6}=11,200$ gallons falling on the roof during the six wet months. Deduct from this one-third wasted, and there is found to have entered the cistern 7,470 gallons. During the period, May to October, 184 days, the amount of water drawn out of the cistern would be 4,600 gallons ($5\times5\times184$), and deducting this from the collected amount (7,470 gallons) leaves 2,870 gallons in storage at the end of October. The latter amount would be the minimum needed capacity of the cistern. Inspection of the table shows that although several selections to hold about 2,870 gallons could be made, perhaps the most suitable size would be 8 feet in diameter and approximately 8 feet in depth. Continuing the calculation for the 6 dry months, $\frac{1,500\times3.2}{1.6}=3,000$ gallons, and deducting one-third for waste, it is seen that 2,000 gallons more would enter the cistern and there would be drawn out 4,525 gallons ($5\times5\times181$). Hence there would be left in the cistern on April 30 a small surplus, 345 gallons ($2,870+2,000-4,525=345$.)

The reader is cautioned that in the foregoing example only mean or average distribution is taken. In nearly every locality there comes at intervals the long drought, the extraordinarily dry year, when rainfall drops to one-half or one-third of the normal. Moreover, many small rains may be impracticable of collection because of the dirty condition of the roof. Therefore the householder who would avoid the inconveniences of a shortage in his cistern supply is fully warranted in planning his installation upon very liberal lines.

Capacity in gallons and barrels ($31\frac{1}{2}$ gallons) of plain cylindrical cisterns and tanks.

Depth of cistern in feet.	Diameter of cistern in feet.																	
	4		5		6		7		8		9		10		11		12	
	Capacity of cistern in gallons and barrels.																	
	Galls.	*Bbls.*	*Galls.*	*Bbls.*	*Galls.*	*Bbls.*	*Galls.*	*Bbls.*	*Galls.*	*Bbls.*	*Galls.*	*Bbls.*	*Galls.*	*Bbls.*	*Galls.*	*Bbls.*	*Galls.*	*Bbls.*
4	376	12	588	19	846	27	1,152	37	1,504	48	1,904	60	2,350	75	2,844	90	3,384	107
5	470	15	735	23	1,058	34	1,439	46	1,880	60	2,380	76	2,938	93	3,555	113	4,230	134
6	564	18	881	28	1,269	40	1,727	55	2,256	72	2,855	91	3,525	112	4,265	135	5,076	161
7	658	21	1,028	33	1,481	47	2,015	64	2,632	84	3,331	106	4,113	131	4,976	158	5,922	188
8	752	24	1,175	37	1,692	54	2,303	73	3,008	96	3,807	121	4,700	149	5,687	181	6,768	215
9	846	27	1,322	42	1,904	60	2,591	82	3,384	107	4,283	136	5,288	168	6,398	203	7,614	242
10	940	30	1,469	47	2,115	67	2,879	91	3,760	119	4,759	151	5,875	187	7,109	226	8,460	269
11	1,034	33	1,616	51	2,327	74	3,167	101	4,132	131	5,235	166	6,463	205	7,820	248	9,306	295
12	1,128	36	1,763	56	2,537	81	3,455	110	4,512	143	5,711	181	7,050	224	8,531	271	10,152	322

CISTERN FILTERS.

That method of filtration which copies most nearly the slow percolation of rainfall into the ground will give the greatest degree of purification. The rate may be kept down to advantage to 1 pint in four minutes (45 gallons in 24 hours) for each square foot of effective area in the filter bed. Sand is one of the best and most available filtering materials, and well-burned charcoal is most useful in removing color, taste, and odor. Fine sand removes minute particles to a greater extent than does coarse sand, but on the other hand it clogs more quickly. Crushed quartz and thoroughly clean pit or beach sand, such as is used in mixing mortar, are employed extensively. The size of the grains should be quite uniform and should be such that all could be sifted through holes made in a sheet of paper by a medium-sized awl or knitting needle. A depth of 2 feet of carefully selected sand free from clay, loam, and vegetable matter, is preferable to a greater depth of sand of indifferent quality. As the thin surface layer becomes clogged with continued use, it

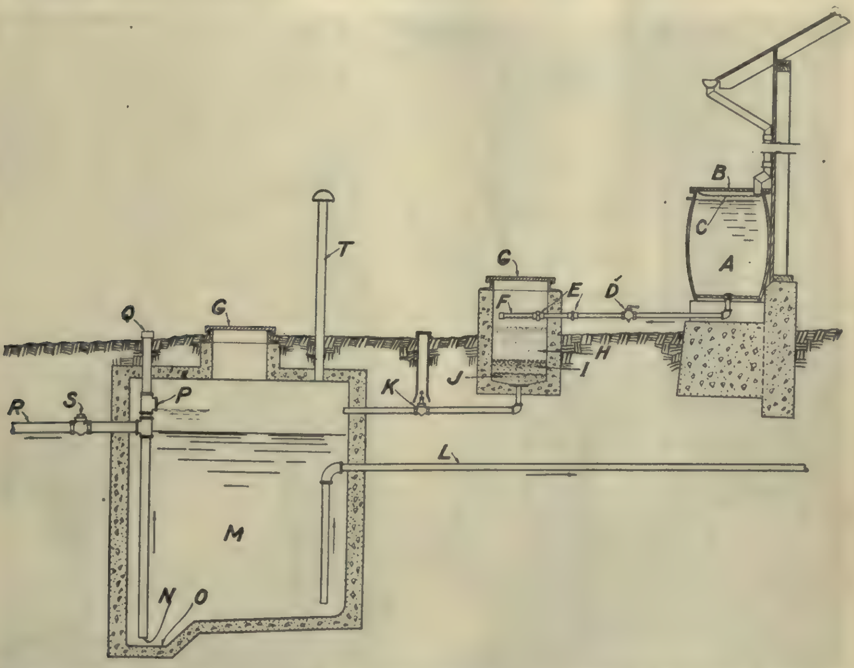

FIG. 4.—Cistern and filter installation. Approximate cost, $150. *A*, Hogshead or large tank; *B*, tight cover; *C*, wire screen; *D*, ¾-inch 2-way rain cock; *E*, ¾-inch union; *F*, ¾-inch brass or galvanized pipe, perforated; *G*, tight overhanging cover; filter box may be wood, iron, brick, concrete, or 4 feet of large-size vitrified pipe; *H*, 24-inch layer fine sand; *I*, 6-inch layer well-burned wood charcoal size of wheat grains; *J*, 2-inch layer of gravel size of a small pea to give support and drainage; *K*, ¾-inch 2-way rain cock with 1 branch piped to waste; *L*, suction pipe; *M*, cistern, side walls 6 to 10 inches thick; *N*, 1-inch overflow; *O*, sump or catch basin; *P*, emergency overflow; *Q*, screw cap (remove cap and attach hand pump when cleaning cistern); *R*, waste pipe; *S*, swing check valve; *T*, screened ventilator. When starting operation, waste the first water filtered; throttle cocks *D* and *K* to give the desired low rate of filtration; maintain water level above sand layer, thus protecting the surface film of mud.

may be scratched or furrowed or a half inch or so may be scraped off with a trowel, until eventually the bed is reduced to 12 or 15 inches in thickness. The sand removed either should be washed and returned, or be replaced with new sand. It is advantageous to place about 6 inches of well-burned charcoal under the 2-foot bed of sand. Triple-burned, triple-ground wood charcoal, the pieces averaging the size of wheat grains, has given excellent results and costs normally about 60 cents a bushel, in sacks, at kilns in eastern States.

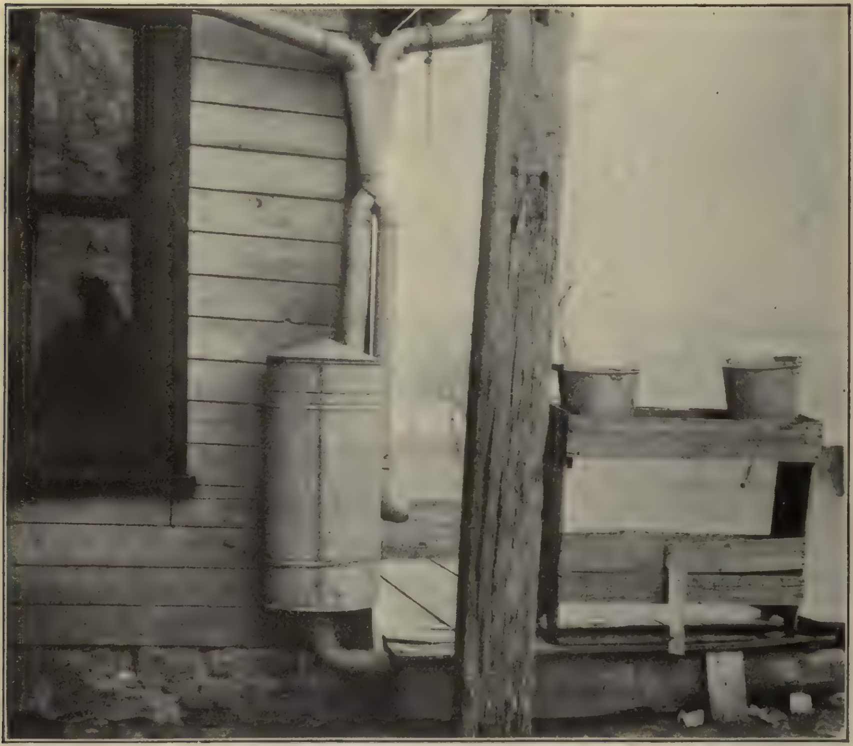

FIG. 5.—Galvanized-iron charcoal filter and rain-water switch. Water passes into a dug well. Not a desirable installation.

A cistern and filter embodying the foregoing principles is shown in figure 4. The construction may be inexpensive, and if the filter is well handled, good results will ensue. As the filter is above ground, it is inspected, cleaned, and aerated readily, but should be drained at the rain cocks or the connections should be protected in cold weather.

Figure 5 shows a galvanized-iron charcoal filter connected with a rain conductor. Above the filter is a switch for diverting and wasting the dirty rinsings from the roof. Within the filter is a piece of cheesecloth supported by galvanized-iron netting beneath which are lumps of charcoal. The filtered water passes to a dug well 25 feet deep. Objections to this installation are: Rapid and mere mechanical straining (not filtering) through a coarse medium and loss of water in the well. If the well were free yielding, as in sand or gravel, the result would be comparable to pouring water into a basket.

SURFACE-WATER SUPPLIES.

Streams, ponds, irrigation ditches, and small open reservoirs are very unsatisfactory, unsafe sources of farm water supply. The temperature of such water seldom is satisfactory, and the presence of more or less polluting matter is certain. Often the carcasses of farm animals are found therein. In thousands of cases the domestic supply is taken directly from irrigation ditches. In other instances a cistern, often without a filter, is filled at such times as the ditch water runs clearest. Often open reservoirs[1] are necessary to collect and store rainfall for the use of stock, and occasionally they are used as sources of domestic water and ice supplies.

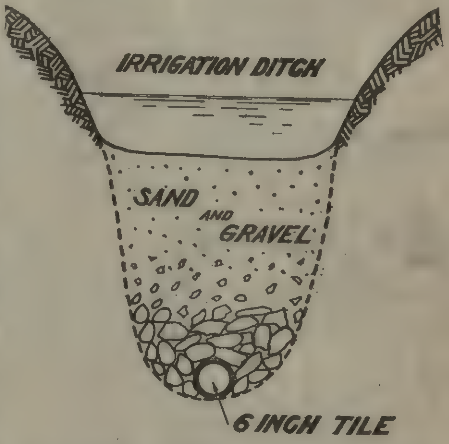

FIG. 6.—Drain tile collector beneath an irrigation ditch, Sevier County, Utah.

Under favorable conditions, where the basin is large and deep (10 feet or more), the bottom free of mud, muck, or other organic matter, the surroundings clean, and the circulation good, the quality of surface water may improve by long storage. However, these conditions are seldom realized on the farm, and the amount of improvement or purification is never certain.

The only safe course is to avoid drinking water from any surface source unless such water has been purified by filtration or sterilized by boiling or by chemicals.[2] Prudence dictates, also, that ice gathered from shallow, unclean sources should not be brought in contact with food and drinking water. It is particularly important to reject snow ice and the first inch or so of clear ice formed.

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[1] For information on reservoir construction, see U. S. Department of Agriculture Farmers' Bulletin No. 592, "Stock-watering Places on Western Grazing Lands;" Office of Experiment Stations Bulletin No. 179, "Small Reservoirs in Wyoming, Montana, and South Dakota;" Office of Experiment Stations Bulletin No. 249, Part I, "Earth-filled Dams and Hydraulic-filled Dams;" Office of Experiment Stations Bulletin No. 249, Part II, "Timber Dams and Rock-fill Dams."

[2] The United States Public Health Service recommends: (1) Boiling 20 minutes. (2) Disinfection with chloride of lime. The disinfecting solution is prepared by dissolving 1 teaspoonful of fresh chloride of lime (bleaching powder) in 1 quart of water. Keep the solution in a tightly stoppered bottle away from light. To disinfect water, add 1 teaspoonful of the solution to each 2 gallons of water, stir thoroughly, and allow to stand 15 minutes before drinking the water. See Public Health Bulletin No. 70, "Good Water for Farm Homes."

Figure 6 shows the method of obtaining water from an irrigation ditch in Sevier County, Utah. A short stretch of the ditch was excavated to an additional depth of about 5 feet, 6-inch drain tile was laid therein and surrounded with coarse gravel, and the refilling was completed with sand. This simple infiltration gallery clarifies the water quite well but is little protection if the supply constantly carries disease germs. Where mud and silt settle so as to clog the sand, relief may be obtained by raking the bottom of the ditch at such times as the flow is strongest.

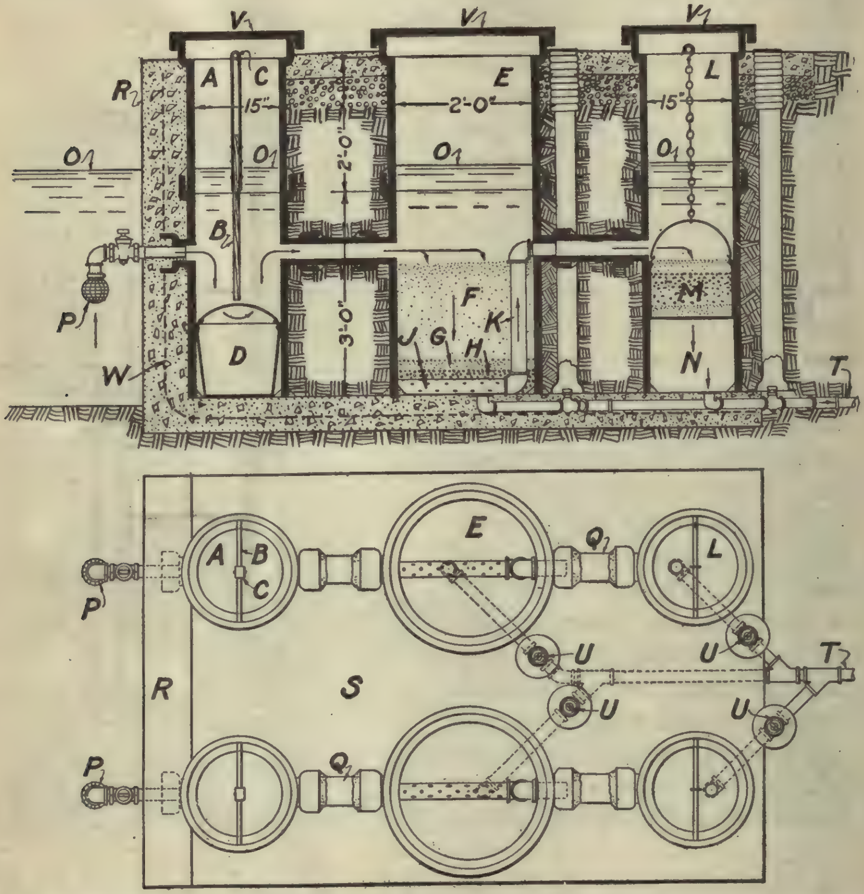

FIG. 7.—Slow sand and charcoal filter in two units. Estimated cost, $125. Chambers are large-size vitrified pipe. All pipe joints made water-tight. Arrows show direction of flow. *A*, Settling chamber; *B*, baffle board suspended by strap iron from rod *C*; *D*, galvanized pail to catch sediment; *E*, sand chamber; *F*, fine sand; *G*, 1-inch layer coarse sand; *H*, 1-inch layer fine gravel; *J*, brass or galvanized, perforated pipe; *K*, riser; *L*, charcoal and filtered water chamber; *M*, galvanized basket or perforated pail held by a chain and crossbar; 6-inch layer of charcoal between restraining layers of fine gravel; *N*, filtered water; *O*, low water level; *P*, inlet pipe with strainer and valve; *Q*, 3-inch vitrified pipe; *R*, retaining wall; *S*, base; *T*, delivery pipe; *U*, valve with extension box to surface; *V*, tight overhanging cover; *W*, steel rods. When the filter is in operation, valve *U* in pipe from chamber *E* is closed; opening this valve and closing inlet valve *P* permits drainage and aeration of the sand; throttle valve *U* on pipe from chamber *L* to give the desired low rate of filtration; waste first water filtered and maintain water level *O* above sand and charcoal.

Figure 7 shows a sand and charcoal filter of simple design to improve the water from irrigation ditches. The filter is arranged in two units. By closing either inlet valve that unit or side may be pumped out, the chambers cleaned, the sand furrowed, scraped, or renewed, and the dirty charcoal replaced with new. If this filter and the one shown in figure 4 are kept clean and are operated at a slow rate, as already suggested, they may be expected to remove nearly all the sediment, to oxidize a portion of the dissolved organic matter, and to eliminate a high percentage of the bacteria (these may include both harmless and harmful varieties as well as organisms causing unpleasant taste and odor). In order to provide a reserve of filtered water that would supply a pump properly or fill a gravity pipe line, it would be necessary to enlarge chamber *N* greatly or lay pipe *T* to a cistern similar to the one shown in figure 4. The rate of filtration then may be unaffected by the rate of pumping, and by trial the opening in valve *U* can be reduced so that the normal daily consumption of water will require the full 24 hours to pass through the filter.

Figure 8 shows the essentials of a homemade slow sand filter[1] used with much satisfaction for many years by Dr. Robert Fletcher, president New Hampshire State Board of Health, and director Thayer School of Civil Engineering, Hanover, N. H. This filter need not cost more than $10. The materials are procurable everywhere, and it can be made and installed by any handy farm laborer.

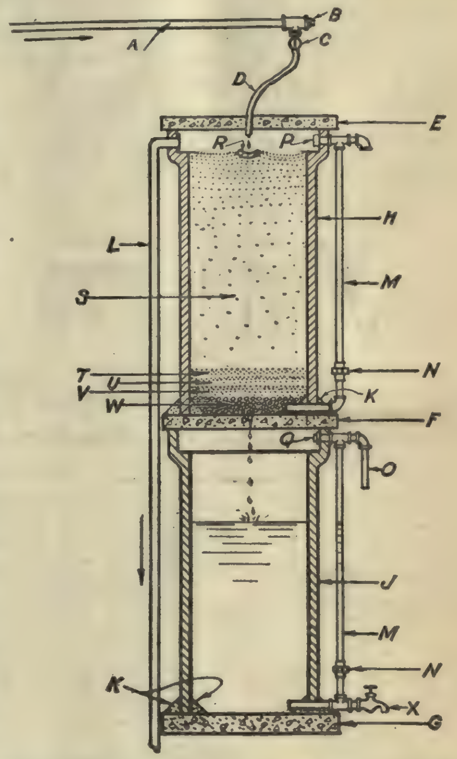

FIG. 8.—Homemade slow sand filter. Capacity, 25 to 30 gallons per 24 hours and costs about $10. *A*, Supply pipe; *B*, brass tee, plugged; *C*, brass pet cock; *D*, rubber tube; *E*, concrete cover; *F*, concrete slab with cone-shaped hole $\frac{1}{32}$ inch in diameter at the bottom of the slab in the center; *G*, concrete base slab; *H*, *J*, 10-inch vitrified pipe, each 2 feet long; *K*, water-tight cement fillet; *L*, overflow, $\frac{1}{2}$-inch lead pipe; *M*, $\frac{1}{2}$-inch glass tube; *N*, $\frac{1}{2}$-inch union; *O*, $\frac{1}{2}$-inch vent and overflow; *P*, tight cap; *Q*, nut, pipe open; *R*, piece of slate, brick, or tile; *S*, clean fine sand; *T*, 1-inch layer of coarse sand; *U*, $\frac{1}{2}$-inch layer of gravel size of shot; *V*, $\frac{3}{4}$-inch layer of gravel size of a pea; *W*, $1\frac{1}{4}$-inch layer of gravel about $\frac{1}{2}$-inch size; *X*, $\frac{1}{2}$-inch brass faucet for drawing filtered water.

Figure 9 shows a tripoli stone (consolidated siliceous ash) pressure filter. It may be placed conveniently in the home and connected with the discharge pipe from a pump or with a gravity pipe line. Pressure forces the water through the pores of the stone in the direction of the arrows, and the filtered water is drawn as required from the faucet *L*. This filter costs about $25 but may be had in different styles and sizes at lesser or greater cost. Pressure filters may be purchased in which the filtering material is sand or sand and charcoal, and their purifying efficiency is greatly increased if they contain a device which automatically feeds a small quantity of alum or other coagulant into the unfiltered water.

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[1] New Hampshire Sanitary Bulletin, July, 1906, and Engineering News, New York, Aug. 9, 1906.

Caution.—A filter is a device for removing dirt from water. It promotes purity and safety but never is a guarantee. It does not excuse the use of water taken from sources known to be contaminated. Filtration alone does not materially affect such dissolved minerals as the water may contain. If, for instance, brine be filtered, the resultant still will be salt water. Not only must the accumulated dirt be removed from filters according to their use and the dirtiness of the water filtered, but the filtering material must be cleaned, aerated, or sterilized from time to time. Dirty sand can be washed, but dirty charcoal should be replaced with new charcoal four or five times a year. Charcoal filters, if neglected, may become a detriment rather than a benefit, due to the storage and overloading of organic matter within the pores and upon the surface of the charcoal.

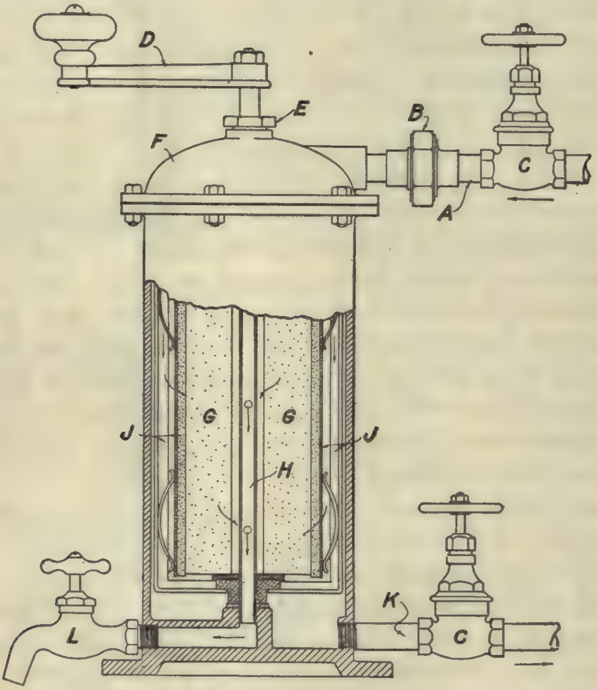

FIG. 9.—Stone pressure filter. *A*, Inlet pipe; *B*, union; *C*, gate valve; *D*, crank; *E*, stuffing box: *F*, removable top; *G*, filtering stone; *H*, center pipe; *J*, cleaning stone and holder; *K*, drain, used when cleaning the filter and flushing out; *L*, filtered water faucet.

GROUND-WATER SUPPLIES.

Good ground water is the ideal supply for the farm. The subject has been so well covered in publications of the United States Geological Survey[1] that this bulletin will record merely some general conclusions and personal experiences. Any farmer about to put down a deep or expensive well, and who is uncertain of the depth and the quantity or quality of the water likely to be encountered, should describe fully the location and conditions of his project to national or State geological authorities and ask for advice. Times without number, wells have been sunk to great depths in the belief that eventually a plentiful supply would be reached, only to find that water was not there, or that it was unfit for use, or that a mere hole or sump had been created which served but to drain water from relatively near the surface. There is no short cut and no better guide in this matter than information as to the kind, thickness, porosity, and dip of the strata of the region and of the results obtained in neighboring wells, study of the land slopes and character of the vegetation,[2] and examination for evidences of seeps and springs.

Regarding the use of a forked willow, hazel, or peach stick for locating underground water, it can be said safely the method is without merit, although so-called forked-stick artists from their experience and observation of surface conditions usually are better able to judge of the probabilities of ground water than is the average person not thus trained. So, also, there is little to recommend certain patented automatic water finders which are based upon the possible, but largely conjectural, proposition that electrical exchanges between the earth and atmosphere are stronger in the vicinity of subterranean waters.

The most likely appearance of seeps and springs is near the base or toe of slopes, and shallow wells similarly located usually are stronger than those higher up the slope or farther out on the flats. Often vegetation is the only visible evidence of the presence of water which, if it reaches the surface, suggests prospects for flowing wells, and even for artesian wells. Wells upon the crown of a hill or close to rock out-crops, are not likely to yield plentifully. The stronger artesian flows usually come from the lower strata.

Sands, gravels, and mixtures of them, porous sandstone (consolidated sand), and conglomerates (consolidated gravel) are the most promising waterbearing materials. Quicksand, clay, and hardpan

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[1] See Water Supply Papers Nos. 255 "Underground Waters for Farm Use" and 257 "Well Drilling Methods," and many others treating of conditions in different States, issued by the Geological Survey, U. S. Department of the Interior.

[2] Due to differences of soil and climate, the criteria developed in one region can not be relied upon with certainty in another locality. In Big Smoky Valley, Nevada, vegetation indicative of shallow-water areas, or, at least, of more than the ordinary supply of moisture were as follows: Salt grass, samphire, buffaloberry bush, giant reed grass, rabbit brush (broom sage), big greasewood, wild roses, and birch, willow, and cottonwood trees. U. S. Geological Survey, Water Supply Paper No. 423, p. 95.

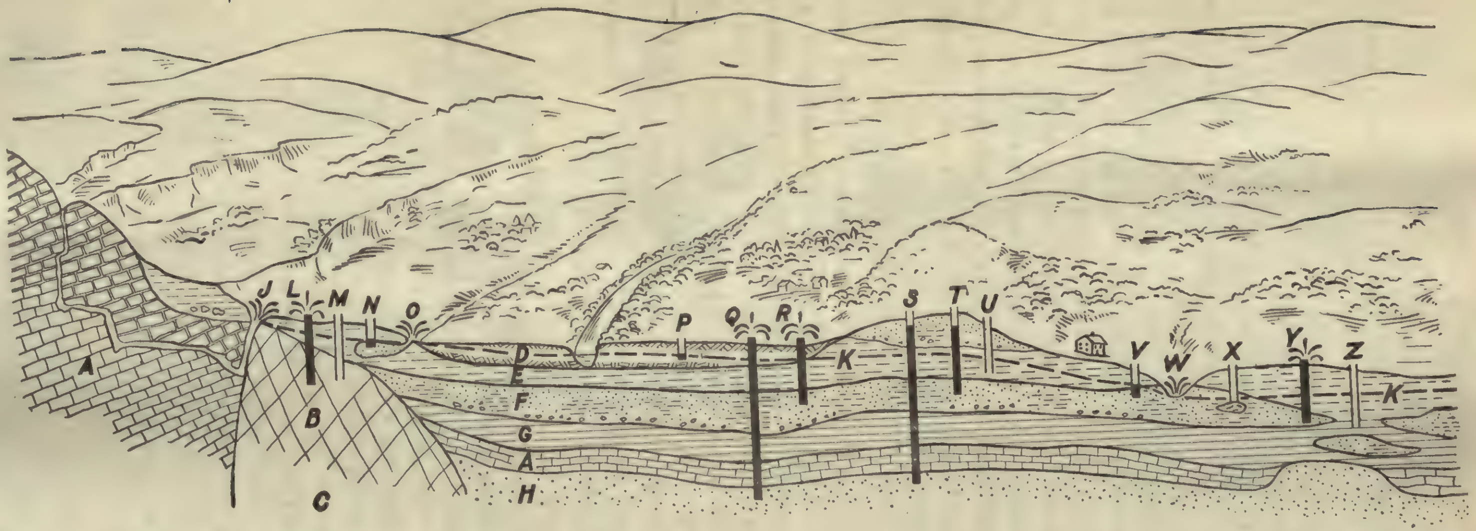

FIG. 10.—Diagram showing how wells and springs may be affected by geologic conditions, surface elevation, and by differences in location and depth. *A*, Limestone showing both small and large passageways; *B*, jointed crystalline rock; *C*, solid crystalline rock; *D*, alluvial soil; *E*, comparatively impervious stratum, as clay; *F*, stratum composed of sand, gravel, bowlders, clay, and mixtures of them; *G*, comparatively impervious stratum, as clay or hardpan; *H*, porous sandstone; *J*, fissure spring (may be contaminated easily by campers or others); *K*, water table or line below which ground is saturated; *L*, flowing well (strikes joints carrying water); *M*, nonflowing well (strikes no joints); *N*, shallow well (strikes a pocket of sand); *O*, seepage spring (yield small and perhaps during wet weather only); *P*, shallow and poor well; *Q*, artesian well (strong flow); *R*, artesian well (bottom in sand, flow moderate); *S*, *T*, nonflowing artesian wells (head insufficient to force water to the surface of the high ground); *U*, well in clay (no yield); *V*, shallow well in sand; *W*, hillside spring (both *V* and *W* are liable to contamination from the house wastes above); *X*, shallow and dry well (bottom in clay and against a bowlder); *Y*, flowing well (bottom in sand); *Z*, dry well (same depth as well *Y* but sunk where the water-bearing bed thins out).

usually contain an abundance of water, but yield it too slowly to afford satisfactory supplies. Among rock formations, shale and slate (consolidated silt and clay) are not good water bearers, but water sometimes is obtained at considerable depths from the joints and cleavage planes. Granite, gneiss, and schist (rocks formed or modified by heat) are likely to be hard and impervious, but due to broken or jointed condition (generally within 300 feet of the surface and seldom below 500 feet) may yield moderate quantities of very good water. Lava rock often yields abundantly, but generally the supply is essentially of surface origin, frequently seepage from irrigation ditches. Limestone and marble carry an abundance of water within the passageways and cavernous channels which characterize these rocks, but the water usually is hard and may be contaminated easily from surface sources. Figure 10 illustrates how differences in slope and underground conditions may give rise to seeps and springs and may cause success or failure in wells of varying location and depth.

SEEPS AND SPRINGS.

Seeps and springs are the natural emergence of ground water upon the surface. If the emergence is slight and diffused over a considerable area, it is spoken of as a seep or ooze; if concentrated, it is spoken of as a spring. In either case, it is water under head and moving where the resistance is least. Hence, anything that reduces resistance, such as open-joint pipes or conduits for the collection of seepage, or excavating within and encasing a spring, tends to increase the yield. On the other hand, increase of resistance, as by accidentally choking the flow, or by building up the curb to a considerable height above the natural surface, tends to decrease the yield, and may cause its loss altogether by deflecting the flow to other channels.

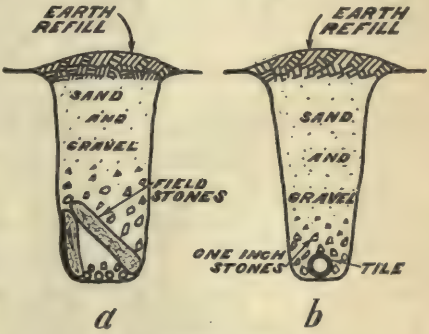

FIG. 11.—Collecting conduits.

Figure 11 (*a* and *b*) show two simple collecting conduits for the capture of seeps. A system very similar to figure 11 (*b*), aggregating 1,758 linear feet of 3, 4, and 6 inch vitrified socket pipe, was laid in Norfolk County, Mass., to collect seepage and the water from several small springs. The pipe was laid to line and grade, strips of burlap 6 to 8 inches wide were placed around the joints and tied with strings, and 4 inches of screened gravel, 1-inch size, was deposited around the pipe for a length of about 10 inches at each joint. Seventy-five joints in muck, quicksand, or clay were closed with jute and cement mortar. Not including the cost of the pipe itself, the cost of labor and materials on this work was $234.72. The result has been a daily yield of 100,000 to 200,000 gallons of good water for about 15 years and the creation of an artificial pond having an area of 4 acres and an average depth of about 8 feet.

Figure 12 shows the method of collecting water upon a farm in California.[1] Trenches 2 feet wide, 4 feet deep, and 1 rod apart were dug across the slope of the hillside and refilled with 3 feet of broken stone over which was a layer of straw and then about 1 foot of earth. These trenches were connected by 4-inch tile drains laid about 18 inches below the surface and running in parallel lines about 2 rods apart down the slope. An outlet to the surface was provided from the lower trench, and an air inlet or vent was inserted at the high end of the upper trench. The soil was of retentive character, and where the stone-filled trenches encountered sand and gravel the sides were sealed with concrete up to the height of the drains to prevent seepage. The two lower trenches were installed first and the others added to increase the yield. Virtually this is an artificial spring.

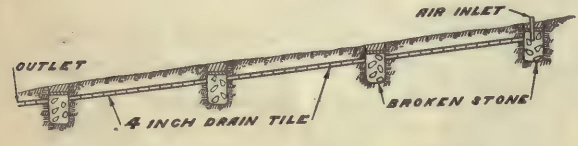

FIG. 12.—Collecting system on a farm in California.

In many instances the water from elevated springs may be piped to the buildings, thus forming a gravity system, a type of installation superior to all others. Figure 13 illustrates such a system. In 1904 the flow of three small springs in Berkshire County, Mass., was collected by a few hundred feet of 2 and 3 inch vitrified pipe laid similarly to figure 11 (*b*). The flow of these springs was 2.6, 3.7, and 7.9 gallons per minute, respectively, and was taken in 2-inch wrought-iron pipe about 1 mile to the point of delivery. Because of a large amount of rock, and to reduce the cost, a considerable portion of the delivery pipe was laid very shallow, and to avoid trouble from freezing the delivery end was so arranged that the flow could not be shut off, except by design. The lowest winter temperatures of the locality run from 15 to 20 degrees below zero, but the owners report never having had trouble from frost and the installation as entirely satisfactory. It is better, however, for the farmer to lay all pipes well below the frost line. Failure to do so often results disastrously.

Springs lower than the farm buildings frequently operate hydraulic rams and force a part of the flow to suitable storage about the premises. Such installations are shown later.

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[1] Described by Messrs. Charles Kellogg and P. C. McNulty, jr.

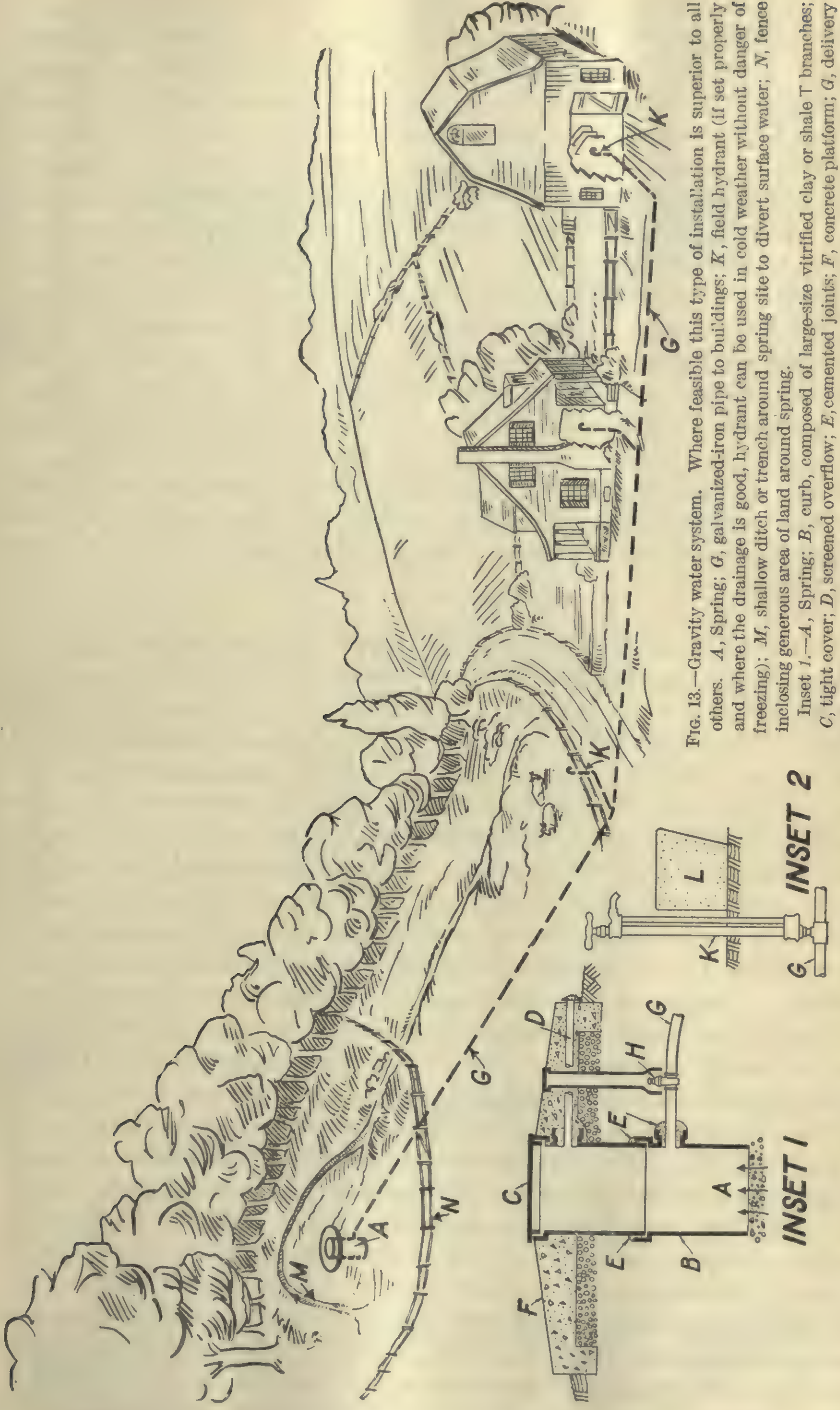

FIG. 13.—Gravity water system. Where feasible this type of installation is superior to all others. *A*, Spring; *G*, galvanized-iron pipe to buildings; *K*, field hydrant (if set properly and where the drainage is good, hydrant can be used in cold weather without danger of freezing); *M*, shallow ditch or trench around spring site to divert surface water; *N*, fence inclosing generous area of land around spring.

Inset *1.*—*A*, Spring; *B*, curb, composed of large-size vitrified clay or shale T branches; *C*, tight cover; *D*, screened overflow; *E*, cemented joints; *F*, concrete platform; *G*, delivery pipe; *H*, gate valve and box.

Inset *2.*—*G*, Delivery pipe; *K*, field hydrant; *L*, watering trough.

WELLS.

Wells are artificial openings in the ground to or below the water table. They should be sunk sufficiently into the water-bearing material so that neither drouth nor the maximum pumping operations of the farm shall so lower the ground water that the pump must be stopped to avoid taking air. Hence no new well should be regarded complete until a pumping test of proper continuous duration has been made to determine its sufficiency for the purposes of the farm and that a mere pocket of water has not been tapped. In shallow wells this can be done usually at slight cost with hand pumps, and in deep wells it is a recognized part of the well business, but should have the personal attention of the person who pays the bill, the farmer. In making the final pumping test the discharge should be taken by pipes or troughs a considerable distance from the well and, if possible, to lower ground.

Wells are spoken of rather loosely as shallow or deep, as dug, bored, driven, or drilled, according to the method of sinking, and in the case of tubular wells, as nonflowing, flowing, or artesian.

DUG WELLS.

Dug wells may be small, as when made with a post-hole digger, or may be very large, the size varying with the freedom with which water enters, the rate of withdrawal or pumping, and the requirements for water. They usually are less than 50 feet deep, although depths of 100 or more feet are not unknown. Often in arid regions wells are not curbed, but in humid sections linings are necessary and are made variously of wood, corrugated iron, stone, brick, vitrified pipe, and concrete. Durability of the curb and water-tightness in its upper portion are highly desirable. Wood never should be used. Stone and brick laid in cement mortar are much to be preferred to curbs laid dry. Data upon corrugated iron and concrete curbs are meager. Bracing a deep excavation, building forms, placing reinforcement and depositing concrete to secure a good job are likely to be costly, especially if much water is encountered. In the arid regions a factor to be considered is the disintegrating action of alkaline water on concrete.[1] Undoubtedly precast, oil-mixed, cement-concrete pipe in 2 to 5 foot lengths with the joints well cemented makes splendid lining, especially if the concrete be reinforced.

Considering cleanliness, tightness, durability, and cost, perhaps no lining is better than heavy, vitrified well tubing, drain tile, or sewer pipe. Either socket or ring pipe may be used. Socket pipe leaves smoother joints inside than does ring pipe, and the joints are more easily made tight. Ring pipe may, however, be made to hold alignment and not separate by means of a series of wooden or iron splices

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[1] See footnote page 12.

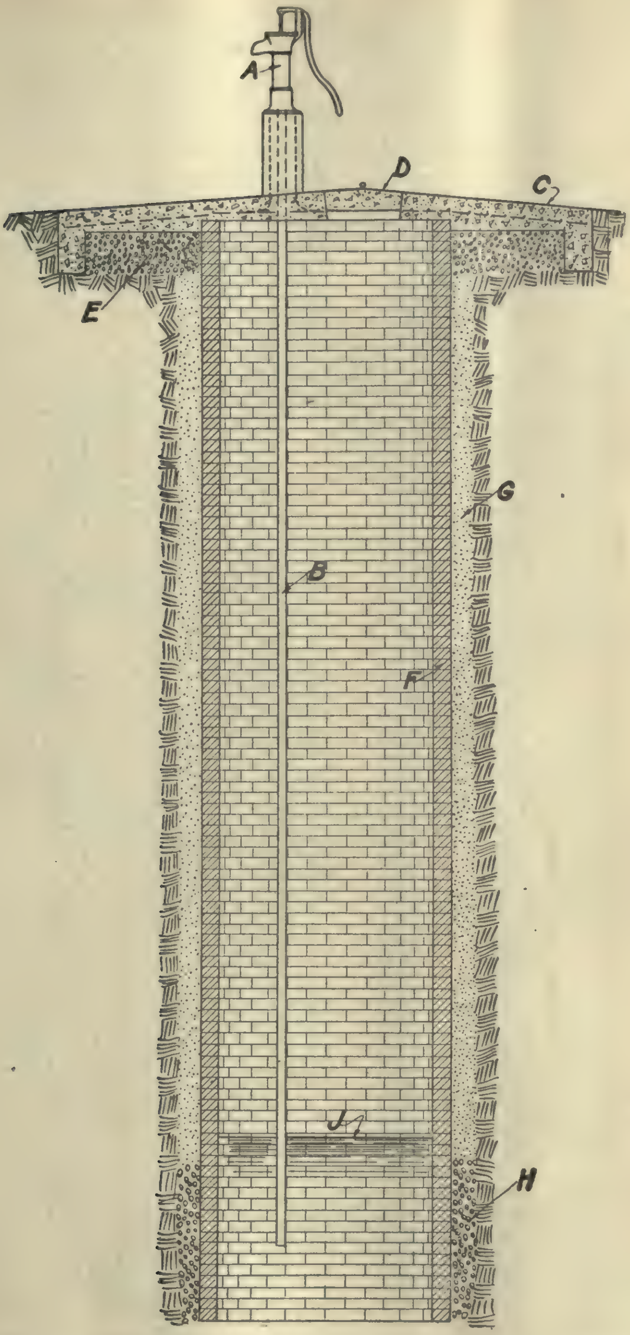

FIG. 14.—Well 23 feet deep in clay soil dug in 1915, Prince Georges County, Md. Manhole and cover shaped by using a large dish pan. Total cost $53.18, and includes pump, 1,800 brick, and purchase of the pail, rope, pick and shovel used in excavating. *A*, Pitcher pump on concrete base 9 inches square and 18 inches high; *B*, 1¼-inch suction pipe; *C*, platform; *D*, manhole; *E*, gravel foundation; *F*, brick curb; *G*, clean sand; *H*, clean gravel; *J*, water level.

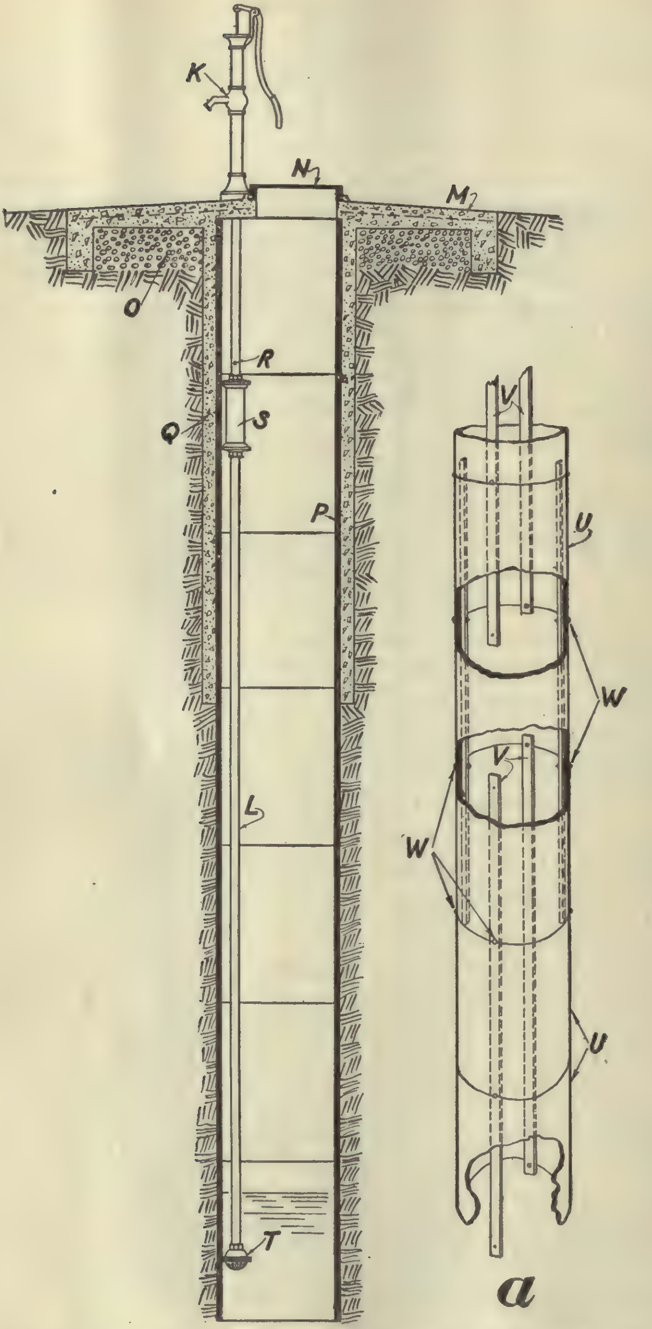

FIG. 15.—Dug well curbed with vitrified ring pipe. Wells of this type 24 inches in diameter and 35 feet deep in fine sand have cost about $200 in Massachusetts (Engineering News, Sept. 7, 1916). *K*, Set-length pump; *L*, suction pipe; *M*, platform; *N*, iron manhole frame and overhanging cover: *O*, gravel foundation; *P*, vitrified ring pipe; *Q*, concrete protection; *R*, drip hole; *S*, cylinder; *T*, foot valve and strainer. (*a*) Shows one method of splicing the pipes for construction purposes; *U*, ring pipe; *V*, 1-inch by 2-inch oak splices; *W*, ½-inch carriage bolts with washers.

bolted to the pipes, and is particularly useful when a well is to be sunk and lined at one operation in relatively soft materials. Long lengths of pipe mean fewer joints.

The excavation for wells 24 inches or less in diameter is made sometimes with a small orange-peel bucket operated by hand with the aid of a tripod derrick. In larger wells a man can work inside the pipe. The material is loosened and placed in a bucket, and another man on the surface raises it with a tag rope or with the aid of a small derrick. The pipe sinks into the excavation thus made, and lengths are added at the surface until the required depth is reached. In loose sand yielding an abundance of water the excavation sometimes is made entirely by the use of a diaphragm or a centrifugal pump. Wells have been sunk in this manner to depths of 30 to 40 feet. By the use of a wooden or steel shoe upon which the curb is started, brick-lined wells 10 to 20 feet in diameter have been thus built, the masons laying the brick at the surface of the ground as the curb sank slowly. Wells sunk in the manner described need not be sheeted and braced, as the curb itself protects. Otherwise, excavations always should be braced carefully to guard against caving and possible loss of life.

Below the water table the space between the curb and the sides of the excavation should be filled with clean sand and gravel, the coarser material being placed at the bottom. The upper 8 or 10 feet of this space should be sealed with concrete or clay. The curb should be brought at least 1 foot above the ground and surmounted by a concrete platform in which is a tight-fitting iron or concrete cover and manhole frame. The platform should slope and the earth be graded away

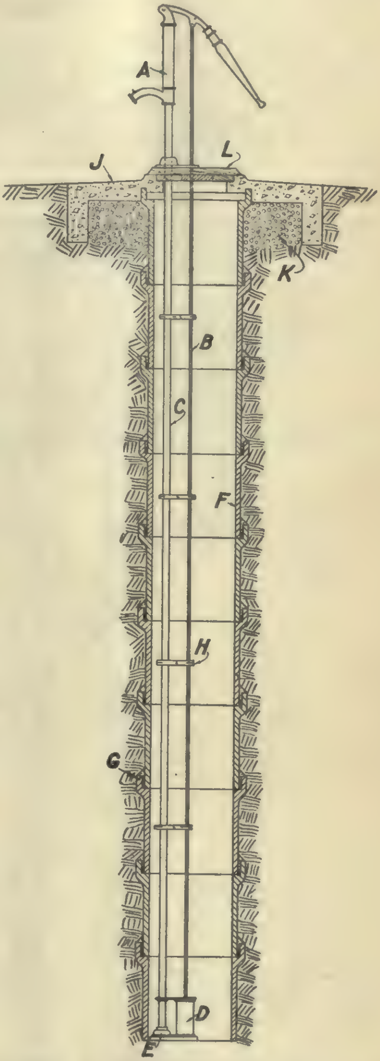

FIG. 16.—Dug well curbed with vitrified socket pipe. *A*, Pump stand; *B*, pump rod; *C*, riser pipe; *D*, cylinder; *E*, check valve; *F*, vitrified socket pipe; *G*, joints packed with a strand of oakum dipped in grout and filled with cement mortar; *H*, pump rod guides; *J*, platform; *K*, gravel foundation; *L*, cross-planked cover.

from the curb so as to shed pump drippings and surface water quickly. Four types of dug well are shown in figures 14, 15, 16, and 17. If properly located, built, and protected, dug wells are more likely to be permanently satisfactory than any other kind. The advantages relate to the larger volume of water immediately available, whereby the pumping may be rapid and the average lift low, and to less liability of trouble with air and sand in suction pipes and pumps.

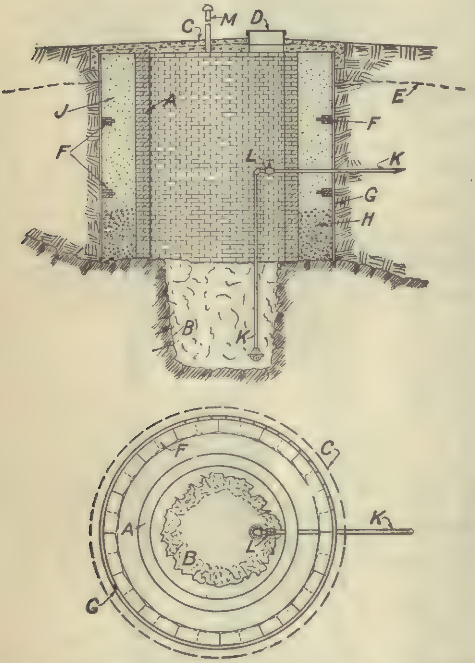

FIG. 17.—Large dug well in rock and caving earth. *A*, Masonry curb; *B*, rock excavation; *C*, platform; *D*, iron manhole frame and overhanging cover; *E*, original surface of ground; *F*, heavy wooden segmental ribs; *G*, heavy grooved sheet piling with hard pine splines or tongues greased before driving; *H*, clean gravel or stone filling; *J*, clean sand filling; *K*, suction pipe; *L*, gate valve; *M*, screened ventilator.

CLEANING DUG WELLS.

Most dug wells require cleaning occasionally. This is due to the entrance of dust or other foreign matter at the top and to the washing in of clay and silt with the ground water. The first step should be inspection of the curb, which, if weak or defective, may make entrance dangerous. This examination may be made more thoroughly, and even the bottom of the well may be observed by the aid of a beam of sunlight reflected into the well by a looking glass. Next, lower a lighted candle to determine if carbonic-acid gas has accumulated in the bottom of the well. Complete or partial failure of the candle to burn indicates that it is dangerous to enter the well. If found safe to enter, a ladder should be lowered and the curb from top down scrubbed with wire or other stiff brushes and rinsed thoroughly. The well then should be pumped as low as possible, and any mud, moss, or other débris should be scraped up into pails and removed. After thorough cleaning, the well should be allowed to fill and then be pumped out rapidly. This operation may be repeated to advantage two or three times, and often the whole work results in a freer, larger-yielding well. Many wells can be drained by hand pumping, but in other cases a power pump is necessary.

Unless there are special reasons for so doing, there is little use in attempting to disinfect wells with chemicals. The volume of water receiving the chemical solution can not be known definitely, and the results are neither certain nor permanent.

TUBULAR WELLS.

"Tubular" is used broadly to include wells variously sunk by boring, driving, or drilling and lined in whole or in part with a tight casing, usually wrought-iron or steel pipe. Such wells may or may not flow, depending upon hydrostatic conditions in the ground. If they go through one or more relatively impervious strata to a more or less confined and porous stratum whose water is under hydrostatic pressure, they properly are called artesian wells, although the head may or may not be sufficient to cause flow at the surface of the ground. (See fig. 10.)

BORED WELLS.

Bored wells are made with earth augers turned and lifted by hand or horse power. The method is adapted to relatively small diameters and depths and to clay, sand, fine gravel, or other comparatively soft material free from bowlders. Two types of earth auger are shown in figure 18 (*a* and *b*). In the type shown in figure 18 (*b*) there is an expansion blade which may be set to cut holes of varying sizes, and there is a movable blade easily opened to release dirt. A small derrick with windlass and block and fall facilitates raising a loaded auger, and a tool resembling a corkscrew is useful in loosening and lifting out small stones. An auger to cut holes from 8 to 16 inches in diameter and including 40 feet of connecting stem (pipe), expansion blades, and tile grapple costs $12 to $13. A mounted well auger, moved and operated by horse power and capable of boring holes 24 inches in diameter and 150 feet deep, is available. Bored wells are lined frequently with hard-burned or vitrified drain tile.

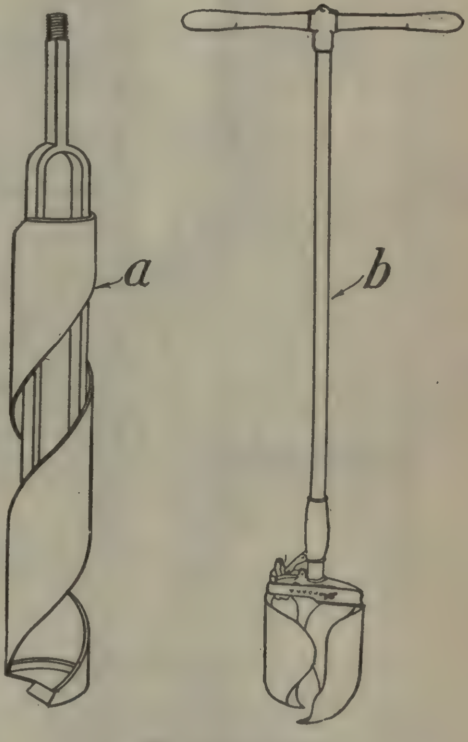

FIG. 18.—Earth augers.

DRIVEN WELLS.

Driven wells are iron or steel pipes forced into a water-bearing bed. Distinction should be made between drive pipe and well casing. Both may be black, galvanized, or asphalted, but drive pipe is heavier and able to stand much pounding. Casing is thinner and is used most frequently to line holes sunk by a water jet, by drilling, or other means. Drive pipe may be had in thicknesses known as standard, extra strong, and double extra strong; also in random lengths (usually between 12 and 22 feet), or, if desired, cut in specified lengths, reamed, threaded, and fitted with couplings. Heavy drive pipe and heavy casing are advisable, as they resist longer corrosion and rough treatment incident to all well-sinking operations. Figure 19 shows the thickness of metal and the common types of joint in 3-inch drive pipe of the several strengths, and of ordinary 3-inch casing.

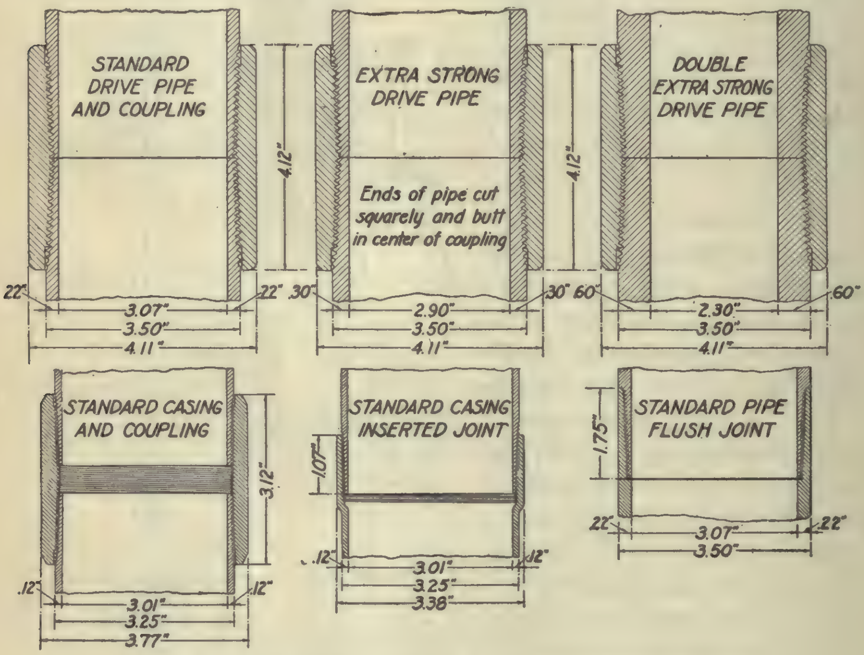
STANDARD DRIVE PIPE AND COUPLING
4.12"
.22"
.22"
3.07"
3.50"
4.11"
EXTRA STRONG DRIVE PIPE
Ends of pipe cut squarely and butt in center of coupling
4.12"
.30"
.30"
2.90"
3.50"
4.11"
DOUBLE EXTRA STRONG DRIVE PIPE
.60"
.60"
2.30"
3.50"
4.11"
STANDARD CASING AND COUPLING
3.12"
.12"
.12"
3.01"
3.25"
3.77"
STANDARD CASING INSERTED JOINT
1.07"
.12"
.12"
3.01"
3.25"
3.38"
STANDARD PIPE FLUSH JOINT
1.75"
.22"
.22"
3.07"
3.50"

FIG. 19.—Sections of typical joints, 3-inch drive pipe and 3-inch well casing.

In the simplest form 1 to 3 inch pipe cut in 5-foot lengths is driven with a heavy striking hammer, sledge, or maul, as shown in figure 20. Other methods of driving whereby heavier weights are used and deeper wells sunk are shown in figures 21, 22, 23, 24, and 25. In figure 24 the weight of the men greatly assists the driving, and the men seem to prefer this direct method of raising the drive block. The first piece of pipe carries a malleable-iron point, either fitting loosely in the end or attached to it. Usually the point is secured to a strainer piece (perforated pipe) 1½ to 3 feet in length, and generally, where the material is silt and fine sand, the perforations are covered with brass gauze protected by an open brass jacket or a wrapping of wire. The threads of every joint should be well coated with a mixture of graphite and cylinder oil. Every joint must be made up tight with pipe wrench or tongs, otherwise, if used as suction, the pipe will leak air, or in driving, the threads may be stripped and the couplings split. The top must have a heavy cap or steel drive head to prevent battering the pipe. In relatively soft material free of bowlders driven wells, as above described, are the quickest and cheapest method of obtaining water. The method is particularly useful in prospecting for water and for temporary supplies. The greatest drawback to such wells lies in the gradual incrustation of the strainer and packing of fine material around it. Very frequently the well must be abandoned in a few years or the pipe pulled and redriven.

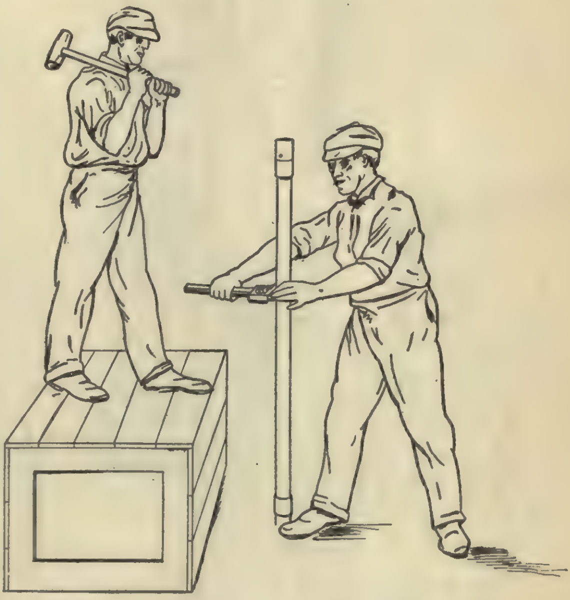

FIG. 20.—Driven well.

Figures 26 and 27 show applications of drive-well points and driven wells. The simple installation shown in figure 27 was long used with complete success both winter and summer on a dairy farm at Westboro, Mass. The sawdust-filled walls were frost proof. In summer the milk-cooling tub was emptied and pumped up two to four times daily, the tempered water passing through a lead pipe into a watering trough. Eventually, the strainer in this well choked, and it became necessary to lay a suction pipe to a distant dug well.

Driven wells of the open-end type are much less subject to obstruction than are those having fine screens, and, with proper development of the well, open-end pipe is used frequently where the sand is extremely fine. The material ahead of the drive pipe is removed with a sand bucket or washed up with the aid of a force pump and a smaller pipe known as the drill or wash pipe dropped inside the drive pipe.

Into the end of the wash pipe is screwed a steel jetting drill which loosens the earth, makes the water jet more effective, and is useful in splitting small stones at the end of the drive pipe. The end of the drive pipe should be protected by an extra heavy coupling or a steel shoe. Using a saw-tooth shoe and turning the entire string of drive pipe at each blow, as shown in figures 20, 21, 22, 23, and 24, materially increases the progress. To facilitate the entry of water the first piece of pipe usually has numerous ¼ or ⅜ inch holes drilled through the shell. The holes should be reamed, preferably on the inside.

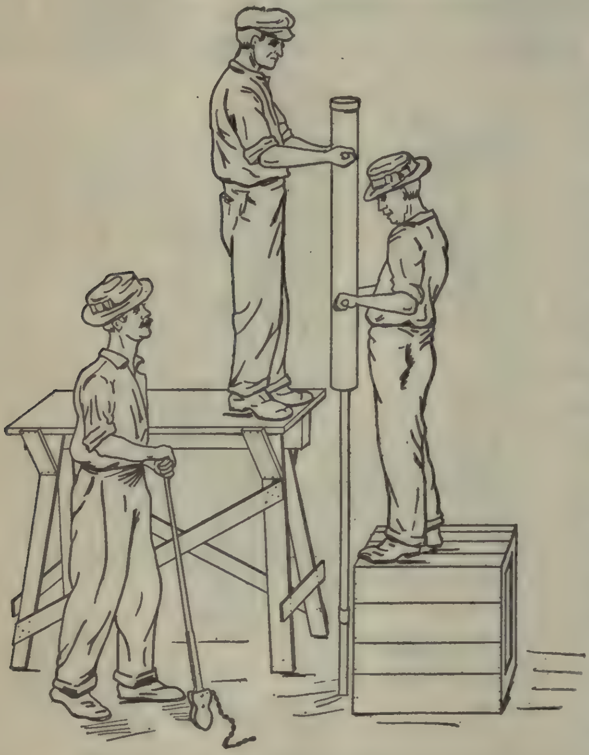

FIG. 21.—Driven well.

Figure 25 shows the application of the jetting process, but it may be used with other methods of driving, as in figures 22, 23, and 24. Simple hand-power outfits are operated readily by three men. Frequently an outfit with one experienced well-driver may be hired for $8 or $10 a day, and with the aid of farm hands, after everything is assembled, a 2 or 2½ inch well may be sunk 50 to 75 feet in a day. Wells always should be tested for yield when the wash water fails to rise to the surface of the ground. Where the material is coarse enough to "lose" the wash water, it is of suitable character to yield freely. Figure 28 shows an open-end driven well.

DEVELOPMENT OF DRIVEN WELLS.

Success or failure with driven wells often is a matter of development. Comparatively few wells yield freely at first, and often the pump handle yanks back quickly, indicating little or no water available. Such wells must be coaxed, and with proper development good yields, sometimes 40 to 50 gallons a minute, may be drawn from them with an ordinary pitcher pump. To develop a well, screw a hand pump to the top of the casing and work the handle slowly and easily. This is to avoid a sudden rush of fine material and consequent choking of the well. Should the well choke, the pump must be detached and the sand removed with a sand bucket or with a jet of water. Gradually, as more and more clay, silt, and fine sand are brought out of the well, the pumping may become more rapid until eventually the pump is worked to utmost capacity. The result often is the creation of a pocket of coarse material about the bottom of the pipe and a yield as free as from a dug well. In the above manner and in material nearly as fine as quicksand several days have been spent upon a single well with gratifying results. A similar effect sometimes is produced by dropping small stones into the well and forcing them out into the adjacent material with a drill.

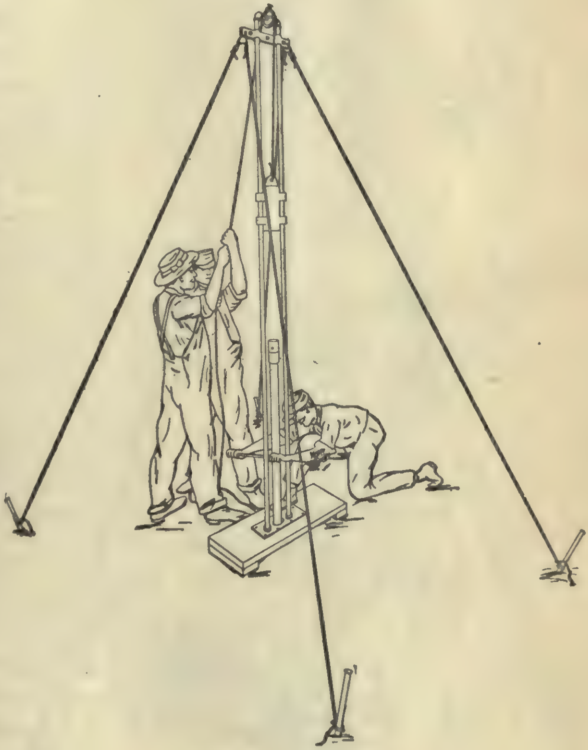

FIG. 22.—Driven well.

DRILLED WELLS.

A drilling outfit is necessary where there is ledge or large bowlders. Generally, a gasoline traction drilling machine is used, and wells are put down by contract or rental by persons equipped for the business. For example, in the vicinity of Twin Falls, Idaho, farm wells are drilled 50 to 150 feet into lava rock at a contract cost of $1 per foot. This cost covers 16 feet of casing, mainly 5⅝ or 6¼ inches inside diameter, through the soil and subsoil. Additional casing, if needed because of loose rock or other material, is paid for by the farmer. It is of value to note that formerly it was necessary to drill about 350 feet to water-bearing sandstone beneath the lava rock, but due to seepage from irrigation ditches, the water table has risen gradually to within 100 feet of the surface of the ground. In the vicinity of Washington, D. C., in September, 1917, $1.38 per foot was bid for drilling and casing (ordinary black 5⅝ inches inside diameter) a well 100 feet or less in depth in clay, sand, gravel, and bowlders.

The yield of drilled wells frequently is increased by shattering the rock with dynamite. This is called "shooting" or "torpedoing" a well and often creates new connections to adjacent passageways carrying water. The method is of little use in unconsolidated materials, and in all instances, because of liability of damage to well or casing or loss of the existing supply, it should be employed only as a last resort. In all well operations a complete record of the kind, depth, and water prospects of each bed or formation should be kept. Frequently it is necessary to pull back a string of pipe, drive it deeper, or perhaps slit it at some water-bearing stratum.

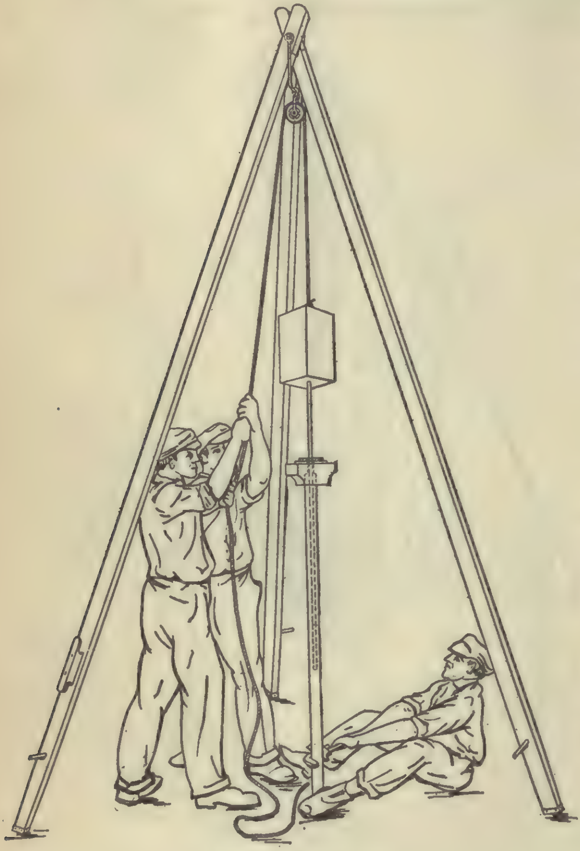
FIG. 23.—Driven well.

INFILTRATION GALLERIES.

Cribs, galleries, and collecting conduits may be defined as horizontal wells. Two examples of galleries are shown in figure 29. Figure 11 (*a* and *b*) shows simple collecting conduits. The construction may be of wood, drain tile, sewer pipe, stone, brick, or concrete, and there should be ample chance, particularly at the bottom, for water to enter. The method is adapted to locations where water is in sheets or thin beds relatively near the surface, or where water is to be taken from the margin of a pond or stream. In the latter case, however, the galleries should be located well back from the stream's edge, at least 50 feet where possible, the idea being to intercept ground water in its movement toward the pond or stream rather than to draw water from them. Galleries should be well below water tables and low-water marks, as otherwise there may be shortage of water during drought. Galleries may be lengthened to increase yields.

METHODS OF RAISING WATER.

Water may be raised by natural flow, hydraulic rams, pumps, air lifts, and air-displacement pumps.

FLOWING WELLS.

Shallow flowing wells are usually short-lived. Artesian flows derived from strata outcropping in distant elevated localities frequently remain strong for many years. In general, however, there is marked tendency toward exhaustion because of reduced pressure and the addition of other wells tapping the same stratum. By using sound, heavy casing and valves to regulate the flow as needed, and by capping or plugging abandoned wells, farmers can aid greatly in conserving artesian supplies.

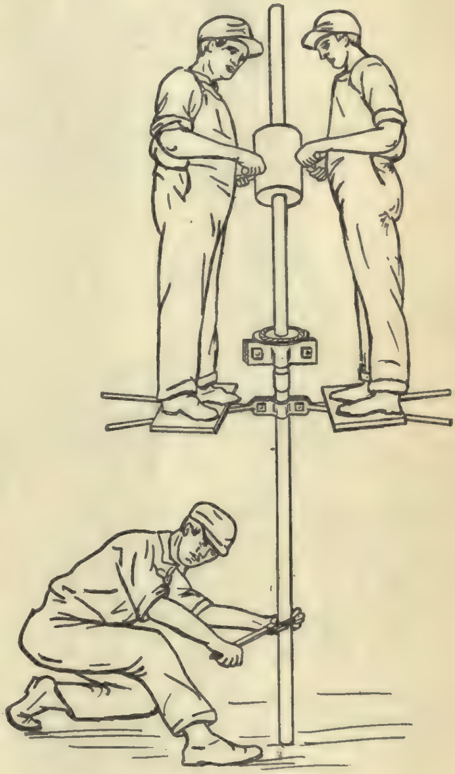

FIG. 24.—Driven well.

HYDRAULIC RAMS.

Although hydraulic rams are an old invention, many people regard them more or less as mechanical toys. They are, however, the most economical pumps known and have been used to raise large quantities of water, as, for instance, the railroad supply at Fort Pierce, Fla., where a battery of four rams is pumping 125,000 to 175,000 gallons daily through more than 2 miles of 6-inch force main.

Hydraulic rams utilize the principle of water hammer. Their operation is as follows: Referring to figure 30, water flows from the source of supply through a straight iron pipe[1] *D* until the velocity is sufficient to force escape valve *E* outward to its seat. Under rest conditions valve *E* is held open by its own weight or a steel spring. Immediately valve *E* seats, the "kick" of the water (water hammer) in pipe *D* opens check valve *C*, through which some of the flow is forced into air chamber *A* and from thence into delivery pipe *B*. Air chamber *A* promotes constancy of pressure and discharge, and pipe *B* may convey water to a higher-situated watering trough, cistern, reservoir, or to an air-pressure tank. As the kick, or hammer, transmitted through the ram is overcome by the greater pressure in pipe *B*, a reaction or backward pulsation is set up which closes valve *C* and unseats valve *E*, whereupon the water in pipe *D* flows again and the whole operation is repeated continuously. The backward

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[1] The drive pipe need not slope but may be horizontal or even vertical. A ram screwed to the top of a 4-inch flowing artesian well was long used to supply an Illinois village. "Some Small Water Pumping Installations," 1902, by Daniel W. Mead, professor of hydraulic engineering, University of Wisconsin.

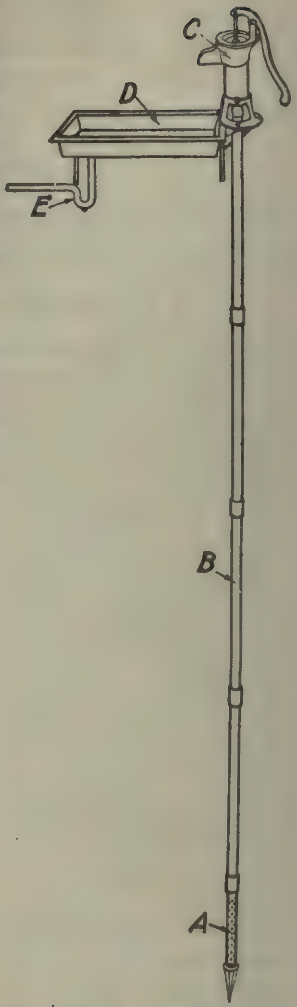

FIG. 26.—Driven well in the home. Where conditions are favorable, this is the quickest and cheapest method of getting ground water to the kitchen sink. *A*, Well point; *B*, drive pipe; *C*, pitcher or kitchen pump; *D*, sink; *E*, lead trap and waste pipe to connect with an absolutely water-tight carrier extending not less than 100 feet in a downhill direction from the well. The cost of a pump, sink, and 1½-inch well 20 feet deep installed as shown should not be more than $20.

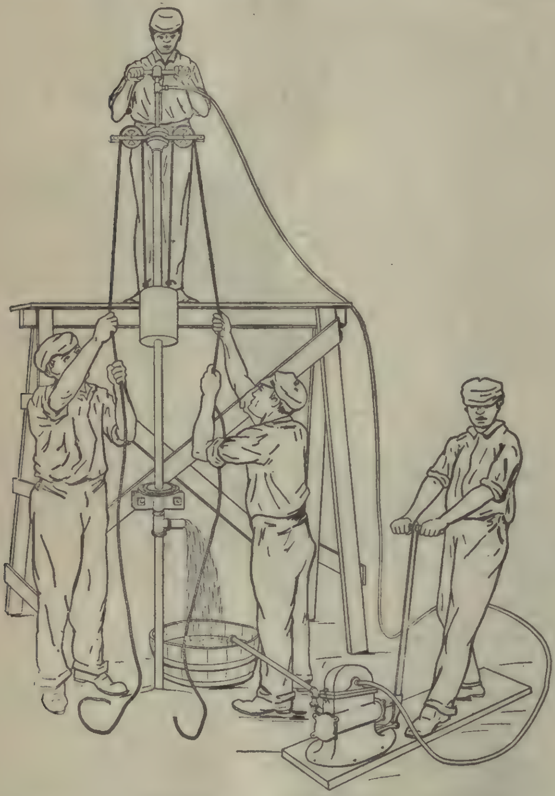

FIG. 25.—Driven well and application of the jetting process.

pulsation or recoil is utilized to suck air through sniff valve *S* and so maintain the supply in chamber *A*. Thus a hydraulic ram automatically pumps water at small cost for power and with little attention. An installation in use nearly 40 years is shown in figure 31.

Rams of different size and make perform differently. Generally, it is necessary to accept the mechanical details determined by the particular manufacturer whose ram is to be used. His instructions should be followed closely, thereby fixing responsibility for results. Manufacturers require the following information: (1) Quantity of water available at ram, gallons per minute.[1] (2) Quantity of water desired at buildings, gallons per day. (3) Available fall, feet (*F* in fig. 30). (4) Horizontal distance in which fall occurs, feet. (5) Lift to reservoir or tank, feet (*L* in fig. 30). (6) Length of delivery pipe, feet. It often is recommended that no ram be installed under a fall (*F*, fig. 30) of less than 3 feet, increasing to 5 or 6 feet with the larger rams; also that no drive pipe shorter than 30 feet be used. Commonly, the diameter of the delivery pipe is about half that of the drive pipe, but it should be increased in size where the discharge is very long, as will be explained in the succeeding caption.

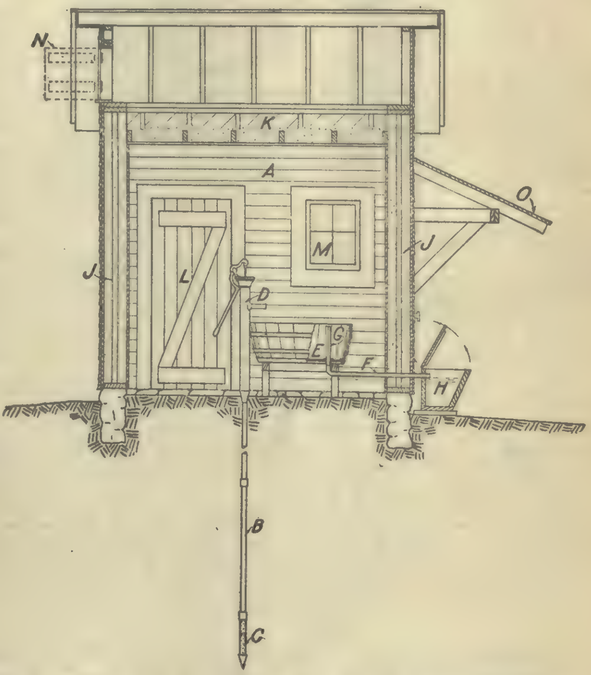

FIG. 27.—Driven well in a milk house. *A*, Milk house, sectional view, showing interior; *B*, drive pipe; *C*, well point; *D*, copper pump; *E*, cooling tub; *F*, lead waste pipe; *G*, wooden plug; *H*, watering trough; *J*, hollow walls, 10-inch space filled with dry sawdust; *L*–*M*, double doors and windows on north side; *N*, door in gable to facilitate placing sawdust; *O*, shed.

The minimum, never more than the average flow of a spring, should determine the size of the ram. Otherwise a ram may be selected which is too large to be actuated by the dry-weather flow. Under average conditions, say where a fall of 3 to 20 feet can be obtained within a distance of 30 to 200 feet of a spring or flowing well, from 3 to 25 per cent of the water entering the drive pipe can be raised to ordinary heights or distances. Obviously, with increase of lift (*L*, fig. 30) less water will be raised, and the fall (*F*) must be greater when operating against high lifts. In exceptional cases, where the lift (*L*) is very small, the amount of the water pumped may exceed the quantity wasted. The approximate quantity of water raised by a good hydraulic ram properly installed may be computed by the following rule:[1] Multiply the number of gallons a minute available for supplying the ram by the fall in feet (*F*, fig. 30). Multiply this product by 40 and then divide by the sum of the fall and lift (*F*+*L*, fig. 30). The result is the number of gallons discharged in one hour, and if multiplied by 24 gives the daily discharge.

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[1] Small flows may be determined by noting the time required to fill a vessel of known capacity. Larger flows may be determined from weir measurements. See U. S. Department of Agriculture, Farmers' Bulletin 813, "Construction and Use of Farm Weirs."

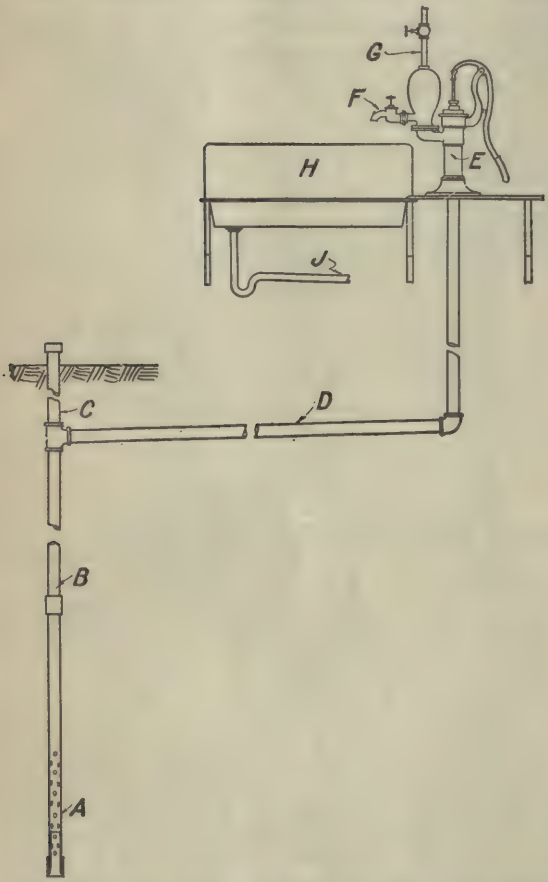

FIG. 28.—Open-end driven well and force pump. *A*, Open-end strainer piece with steel shoe; *B*, drive pipe; *C*, screw cap above ground surface, thus facilitating examination and cleaning of well; *D*, suction pipe laid below frost and on a smooth, upward slope to pump; *E*, force pump; *F*, spout and shut-off; *G*, delivery pipe and valve; *H*, sink; *J*, lead trap and waste pipe to connect with an absolutely water-tight carrier extending not less than 100 feet in a downhill direction from the well.

Where the supply is far from the ram site it is usual to pipe the flow to an open tank, reservoir, or standpipe located so as to secure the desired length and fall of drive pipe. Experience has proved, however, that long drive pipes and high power heads may be used successfully where ample waterway area in the check valve and ample air-chamber capacity are provided. The tank, reservoir, or stand pipe inserted at the upper end of the drive pipe should be protected from frost, and its top must be above the water level of the source of supply as shown in figure 32. Sometimes the flow of a spring is too small to actuate a ram but is sufficient for domestic requirements. In such instances and where a near-by brook can be dammed so as to obtain the necessary power head, the backward pulsation or recoil in a ram may be employed to admit the spring water which is pumped by the fall of the brook water in the drive pipe. Figure 32 shows this method.

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[1] Based on a mechanical efficiency of $66\frac{2}{3}$ per cent (D'Aubuisson formula). Many farm rams operate at 20 to 40 per cent efficiency, but under favorable conditions the best rams may develop from 70 to 90 per cent.

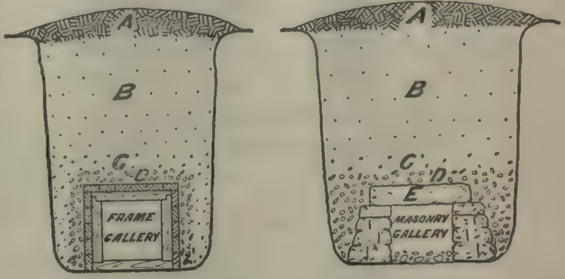

FIG. 29.—Infiltration galleries. *A*, Earth refill; *B*, sand and gravel; *C*, 6-inch layer of screened gravel ⅛ to ½ inch in size; *D*, 6-inch layer of screened gravel, ½ to 1¼ inch size; *E*, covering stone. The frame gallery has been used constantly 27 years. Always submerged, the wood is preserved fairly well, but silt and quicksand gradually are filling up the gallery.

A hydraulic ram should be fastened to a suitable foundation and be housed properly. The waste pipe from the ram pit should be of good size and not subject to backwater or other obstruction. All joints in the drive and discharge pipes should be tight. (See methods of making tight joints, p. 33.) Bends in the drive pipe are a detriment, but if unavoidable should be of gentle curvature, leaving the bore unrestricted. Full-way gate valves should be used to lessen friction. The upper end of the drive pipe may be made bell-shaped to facilitate entry of water, and should be submerged at least a foot to prevent sucking air, and should have a strainer with openings totaling three to five times the cross-sectional area of the pipe. Rubber

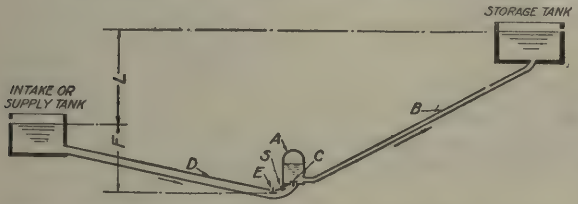

FIG. 30.—General layout of a hydraulic ram installation. *D*, Drive, feed, or supply pipe; *E*, escape, waste, impetus, dash, or clack valve; *C*, check, delivery, or discharge valve; *A*, air chamber; *B*, delivery or discharge pipe; *S*, sniff or air valve; *F*, fall, supply head, or power head; *L*, lift, discharge head, or pumping head.

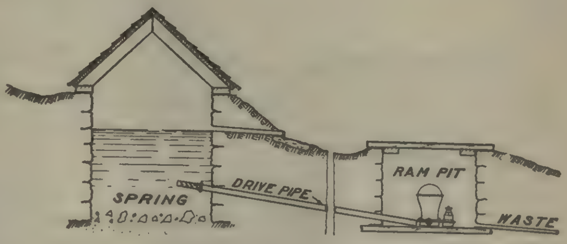

FIG. 31.—Hydraulic ram installed in 1878 and in use nearly 40 years, Worcester County, Mass. Ram pit and spring curbed roughly with field stones. Delivery pipe about one-third of a mile long and supplies two watering troughs in a dairy barn holding about 30 head of stock. Total cost of installation, not including delivery pipe, was $75. Labor was paid $1.75 per day.

valves are less noisy than metal, but where the pounding is objectionable, as it may be in a dwelling, an air chamber and a piece of rubber hose inserted in the delivery pipe ends the trouble.

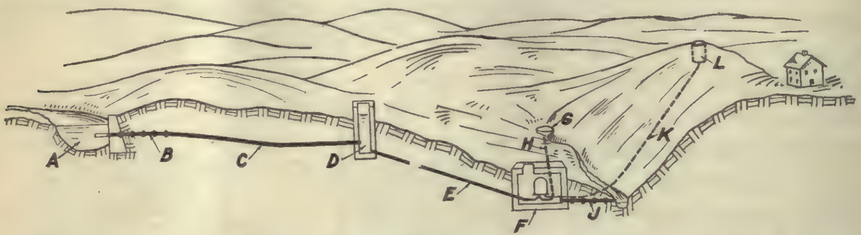

FIG. 32.—Method of using a distant surface supply to raise clear spring water. *A*, Surface supply; *B*, supply pipe (may be vitrified pipe for a portion of the way, where the pressure is small); *C*, iron supply pipe; *D*, standpipe; *E*, drive pipe; *F*, ram; *G*, spring; *H*, spring-water supply pipe; *J*, waste pipe; *K*, delivery pipe; *L*, elevated reservoir.

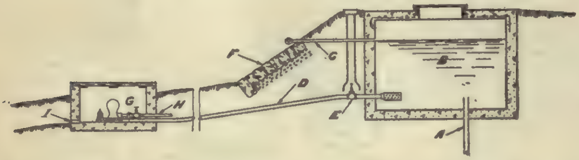

FIG. 33.—Hydraulic ram installation, St. Marys County, Md. *A*, 1½-inch well flowing 4 gallons a minute; *B*, concrete supply tank; *C*, screened overflow; *D*, 1¼-inch drive pipe; *E*, gate valve; *F*, paved slope; *G*, ram; *H*, ¾-inch delivery pipe to storage tank; *I*, wasteway.

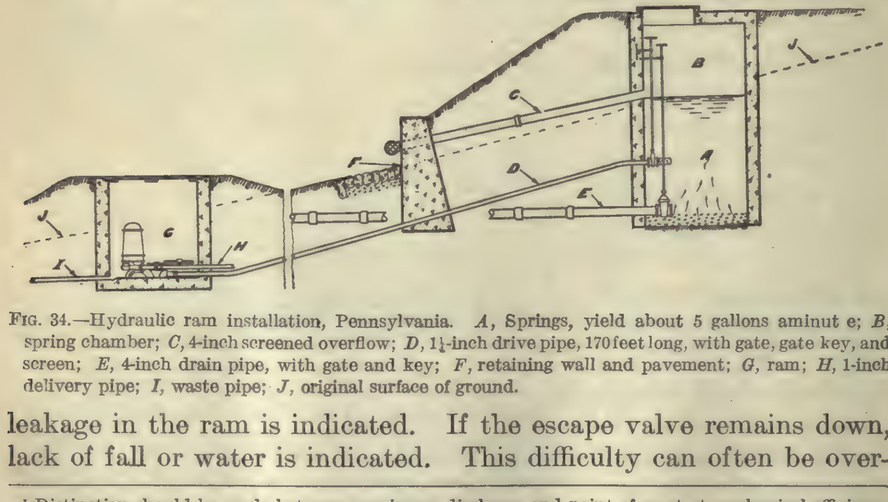

FIG. 34.—Hydraulic ram installation, Pennsylvania. *A*, Springs, yield about 5 gallons a minute; *B*, spring chamber; *C*, 4-inch screened overflow; *D*, 1½-inch drive pipe, 170 feet long, with gate, gate key, and screen; *E*, 4-inch drain pipe, with gate and key; *F*, retaining wall and pavement; *G*, ram; *H*, 1-inch delivery pipe; *I*, waste pipe; *J*, original surface of ground.

Every newly installed ram requires adjustment. Action may be induced by intermittently pressing down on the waste valve and allowing it to rise with the escape of water. The travel of the escape valve and the rapidity of its strokes should be regulated by experiment (by sight, sound, and inference) until its movements have been brought into unison with the natural "beat" or pulsations in the drive pipe.[1] If the escape valve remains up, excessive pressure or leakage in the ram is indicated. If the escape valve remains down, lack of fall or water is indicated. This difficulty can often be overcome partially by plugging two (one on each side) or more of the small holes in the plunger. Should the ram operate and discharge no water, lack of air in the air chamber is probable.

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[1] Distinction should be made between maximum discharge and point of greatest mechanical efficiency (useful work taken out divided by whole work put in). For example, a ram running 37 strokes a minute used in that time 13.1 gallons of which 10.1 gallons were wasted and 3 gallons were pumped, the mechanical efficiency being 41 per cent. When speeded to 72 strokes a minute the mechanical efficiency was 55 per cent, but the ram used only 4 gallons of which 2.9 gallons were wasted and 1.1 gallons were pumped.

Figure 33 shows a ram installation upon a farm in St. Marys County, Md. The supply is obtained from a 1½-inch flowing artesian well 265 feet deep and is raised to an elevated tank in the house yard. Figure 34 shows a design for a Pennsylvania farm where the supply is taken from springs and raised to an underground concrete reservoir (fig. 44) on a hill near the buildings.

FRICTION LOSS AND PUMPING HEAD.

Where a ram or other pump is to deliver water through a very long pipe or into an air-pressure tank, other factors enter in to increase the true pumping head. Motion of water produces friction, a form of resistance that increases with the length and roughness of the pipe and the rapidity with which the water moves. Hence, wherever much water is to be delivered through a long pipe, the power or head necessary to overcome friction should be determined. This is called friction loss or friction head. In effect, it increases just so much the vertical height against which a pump operates. Bends, especially sharp turns, in a pipe line also increase the friction, but ordinarily the farmer may neglect this loss in discharge pipes. Excessive loss due to friction may be avoided by increasing the size of the pipe. The table[1] following shows the friction head (number of feet to be added to the vertical height) for each 100 feet of iron pipe (not new) to overcome friction when discharging given quantities of water. The comparative discharging power of pipes of the several sizes also is shown.

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[1] Hydraulic tables, Williams and Hazen, N. Y., 1909. Coefficient here used is 100, a fair value where the interior of iron pipe is somewhat roughened by rust and sediment.

Friction head or loss and comparative discharging power of pipes.

Discharge in gallons per minute.	Diameter of pipe in inches.												
	¼	⅜	½	¾	1	1¼	1½	2	2½	3	4	5	6
	Friction loss in feet for each 100 feet length of pipe.												
0.5	7.8	......	......	......	......	......	......	......	......	......	......	......	......
1	28.0	6.4	2.1	......	......	......	......	......	......	......	......	......	......
2	103.0	23.3	7.4	1.9	......	......	......	......	......	......	......	......	......
3	......	49.0	15.8	4.1	1.26	......	......	......	......	......	......	......	......
4	......	......	27.0	7.0	2.14	0.57	0.26	......	......	......	......	......	......
5	......	......	41.0	10.5	3.25	.84	.40	......	......	......	......	......	......
6	......	......	......	14.7	4.55	1.20	.56	0.20	......	......	......	......	......
8	......	......	......	25.0	7.8	2.03	.95	.33	0.11	......	......	......	......
10	......	......	......	38.0	11.7	3.05	1.43	.50	.17	......	......	......	......
12	......	......	......	......	16.4	4.3	2.01	.70	.24	......	......	......	......
14	......	......	......	......	22.0	5.7	2.68	.94	.32	......	......	......	......
16	......	......	......	......	28.0	7.3	3.41	1.20	.41	......	......	......	......
18	......	......	......	......	......	9.1	4.24	1.49	.50	......	......	......	......
20	......	......	......	......	......	11.1	5.2	1.82	.61	0.25	......	......	......
25	......	......	......	......	......	16.6	7.8	2.73	.92	.38	0.09	......	......
30	......	......	......	......	......	23.5	11.0	3.84	1.29	.54	.13	......	......
35	......	......	......	......	......	......	14.7	5.1	1.72	.71	.17	......	......
40	......	......	......	......	......	......	18.8	6.6	2.20	.91	.22	......	......
45	......	......	......	......	......	......	23.2	8.2	2.76	1.15	.28	......	......
50	......	......	......	......	......	......	......	9.9	3.32	1.38	.34	0.11	......
60	......	......	......	......	......	......	......	13.9	4.65	1.92	.47	.16	......
70	......	......	......	......	......	......	......	18.4	6.2	2.57	.63	.21	......
80	......	......	......	......	......	......	......	23.7	7.9	3.28	.81	.27	......
90	......	......	......	......	......	......	......	......	9.8	4.08	1.00	.34	......
100	......	......	......	......	......	......	......	......	12.0	4.96	1.22	.41	......
120	......	......	......	......	......	......	......	......	16.8	7.0	1.71	.58	0.24
140	......	......	......	......	......	......	......	......	22.3	9.2	2.28	.76	.32
160	......	......	......	......	......	......	......	......	......	11.8	2.91	.98	.40
180	......	......	......	......	......	......	......	......	......	14.8	3.61	1.22	.50
200	......	......	......	......	......	......	......	......	......	17.8	4.4	1.48	.61
240	......	......	......	......	......	......	......	......	......	25.1	6.2	2.08	.86
Comparative discharging power of pipes[1]	.03	.08	.16	.47	1	1.8	2.9	6.2	11.1	18.0	38.3	68.9	111.3

---

[1] Based on diameters raised to the 2.63 power. Comparative discharges are fair approximations only. Discharge depends not only upon size of pipe but upon velocity of flow, a factor that changes with the relation of head of water to length of pipe. Inspection shows that doubling the diameter of a pipe increases the discharging power or capacity about 6 times.

A column of water 1 foot high and having a base equal in area to 1 square inch weighs about $\frac{7}{16}$ of a pound, and of course presses that amount on the base. Double the height, and obviously both the weight and the pressure are doubled. Hence it may be taken for granted that the pressure of water at rest (static pressure or head) is in direct proportion to the vertical height or depth of the water. From the above the table following is computed.

Vertical height in feet and equivalent pressure in pounds per square inch.

Height.	Pressure.	Height.	Pressure.	Height.	Pressure.
Feet.	*Pounds.*	*Feet.*	*Pounds.*	*Feet.*	*Pounds.*
1	0.43	20	8.67	75	32.51
2	.87	25	10.84	80	34.68
3	1.30	30	13.00	85	36.85
4	1.73	35	15.17	90	39.01
5	2.17	40	17.34	95	41.18
6	2.60	45	19.51	100	43.35
7	3.03	50	21.67	110	47.68
8	3.47	55	23.84	120	52.02
9	3.90	60	26.01	130	56.36
10	4.33	65	28.18	140	60.69
15	6.50	70	30.35	150	65.03

An example will show the use of the last two tables. What is the pumping head where a ram or other pump is delivering 3 gallons a minute through 1,000 feet of 1-inch pipe to an air-pressure tank carrying 39 pounds per square inch situated 20 feet higher than the ram? Solution: To the vertical height water is raised, 20 feet, must be added friction loss, 12.6 feet $\left(\frac{1,000}{100} \times 1.26\right)$ and equivalent height of the 39-pound tank pressure, which is 90 feet, $20+12.6+90=122.6$ feet, the true pumping head (dynamic head).

PUMPS.

The principle underlying the operation of pumps is the displacement of water from a casing, tube, barrel, or cylinder by a movable piston, plunger, or impeller. The medium through which power is transmitted to the piston is called the stock, stand, standard, or working head. Farm pumps usually are suction, lift, force, deep-well, or some combination of these types.

Suction and lift pumps do not raise water above the pump nor discharge it under pressure. Suction pumps require the cylinder to be above the water level of the supply. If a perfect vacuum could be created within the cylinder, water could be raised vertically by suction 33.9 feet at sea level. Due, however, to pump imperfections, air leaks, and vapor and air in water itself, actual suction lift is usually not more than two-thirds of the theoretical height which, together with atmospheric pressure, diminishes with elevation above sea level. The following table gives the limiting suction lift for the satisfactory operation of pumps at stated elevations up to 8,000 feet above sea level.

Limiting suction lift of pumps (vertical distance from water level to top of cylinder).

Elevation above sea level.	Atmospheric pressure reduced to equivalent head of water.	Limiting suction lift.[1]
Feet.	*Feet.*	*Feet.*
0	33.9	22.0
1,000	32.6	21.2
2,000	31.4	20.4
3,000	30.2	19.6
4,000	29.1	18.9
5,000	28.0	18.2
6,000	27.0	17.5
7,000	26.0	16.9
8,000	25.0	16.2

[1] Taken as 65 per cent of the heads shown in the middle column.

Suction pipes must be absolutely air-tight. Methods of making tight joints are described under Driven Wells, page 33. Horizontally, suction pipes may extend long distances,[1] provided the friction loss (see table, p. 44) plus the vertical height from water level to pump valve does not exceed the limiting suction lifts shown in the table preceding. Suction pipes should be straight, slope uniformly upward from well to pump, and never be smaller than the suction connection on the pump. Long lines should be of larger size than such connection and should have a vacuum chamber near the pump and a foot valve on the end in the well. A strainer on the end prevents entrance of obstructions. The strainer may be combined with the foot valve and always the total area of the openings should be large. Figures 14, 26, and 27 show simple suction pumps with cylinders forming a part of the standards.

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[1] Suction pipes 100 to 1,000 feet long are frequent. One nearly 1¼ miles in length has been used many years by a town in Massachusetts.

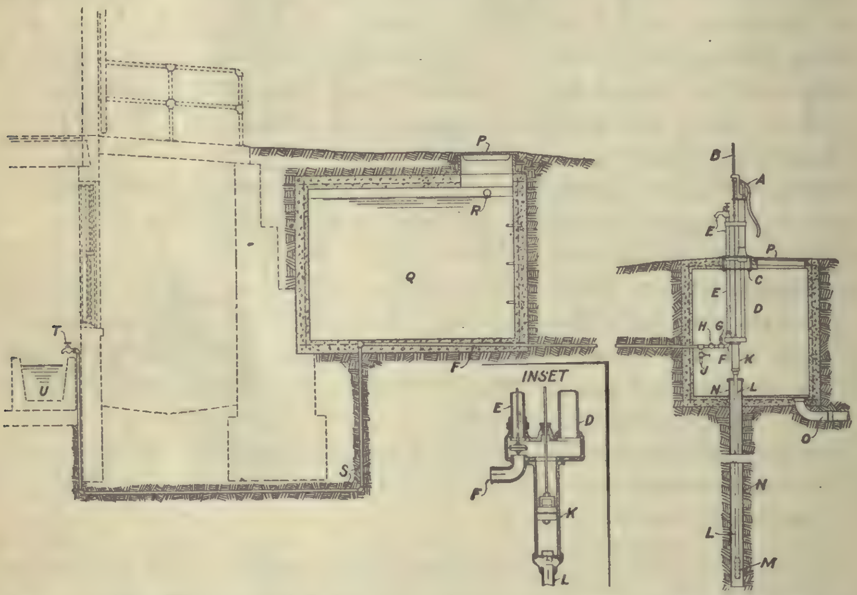

FIG. 35.—Combined hand and windmill force pump, with underground and surface discharges and storage tank under driveway to second story of barn. *A*, Pump; *B*, connecting rod; *C*, clamp to secure standard to concrete; *D*, air chamber; *E*, surface discharge pipe; *F*, underground discharge pipe; *G*, relief valve; *H*, check valve; *J*, waste and blow-off; *K*, pump cylinder; *L*, suction pipe; *M*, strainer; *N*. well casing; *O*, 4-inch drain; *P*, cast-iron frame and manhole cover; *Q*, storage tank; *R*, overflow; *S*, supply pipe to trough; *T*, faucet; *U*, watering trough. Inset shows details of pump cylinder and connections; letters refer as above.

Where a pump can not be placed so that the limiting suction lifts mentioned in the table will not be exceeded, it is necessary to lower the pumping cylinder into the well, raising water from the cylinder to the spout by the direct lift of the piston. A set-length lift pump (sufficient pump or connecting pipe and plunger rod to place the bottom of the cylinder 4 feet below base of standard) is shown in figure 15. This type of pump is used in wells 25 to 28 feet deep. However, water can be pushed more easily than it can be pulled, and hence rather than resort to extreme suction lifts it is preferable to lower the cylinder to within 15 feet of the supply, or still better, to submerge it. Submergence keeps the cylinder primed and the pump leathers pliable. With the cylinder thus lowered into or near the water, this type of pump may be used in very much deeper wells, the depth varying with the weight of the pump, the size of the cylinder, and the power. A drip hole drilled in the connecting pipe a few feet below the platform (always above the cylinder) allows the water to drop back to that point, and, providing the platform is tight, prevents freezing.

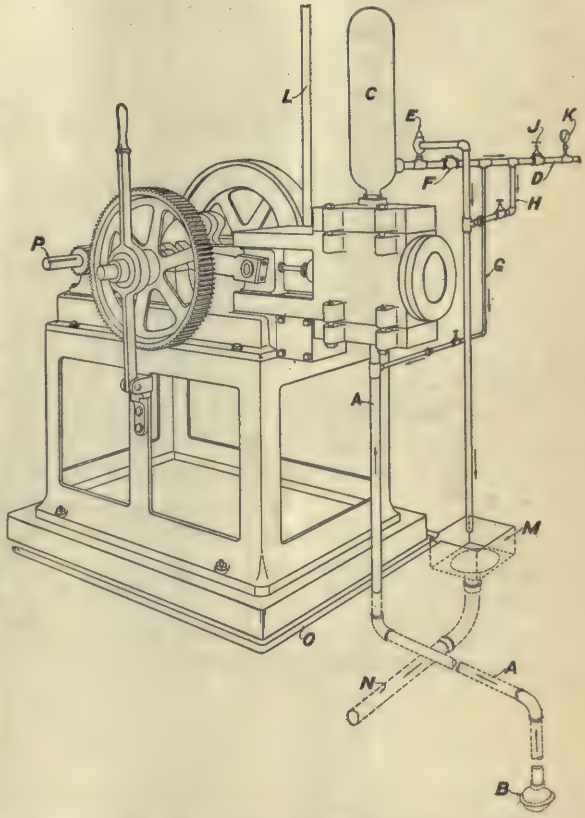

FIG. 36.—Pumping unit, consisting of a double-acting, suction-lift pump and 2-horsepower gasoline engine. *A*, 1½-inch suction pipe; *B*, foot valve and strainer; *C*, air chamber; *D*, 1¼-inch discharge pipe; *E*, relief valve; *F*, check valve; *G*, ½-inch charging or priming pipe; *H*, waste and blow-off pipe; *J*, gate valve; *K*, pressure gauge; *L*, engine exhaust above roof; *M*, sump in floor; *N*, 4-inch drain; *O*, floor gutter; *P*, shaft for attaching pulley to drive other machinery. An equipment having a rated capacity of about 17 gallons a minute and erected complete, as shown, at a point 500 miles from the factory, costs approximately $300. (March, 1918.)

Where water is discharged against pressure a force pump is necessary. A combined suction and force pump installed at a kitchen sink is shown in figure 28. Delivery pipe *G* may be taken to an attic tank or an outside elevated reservoir, and thus a light pressure supply be maintained throughout the house. Figure 35 shows a combined hand and windmill force pump with discharge either below or above ground. Figure 36 shows a suction and force pump driven by a gasoline engine, both mounted on one base.

Deep-well pumps are heavier and stronger than those heretofore described. They may be of the lift or force type, and the standard or working head always is directly over the well. Two methods of supporting the working barrel or cylinder are used. In one method a plain tubular cylinder about one-fourth inch smaller than the bore of the well is attached securely at the desired depth to the well pipe or casing. In the second method the working barrel screwed to a connecting or drop pipe is hung from the standard or working head. With either method the cylinder should be near (within 15 feet) or else below the lowest water level which pumping and drouth may create. (See Wells, page 26.) Submergence always is preferable. In the first method there is no drop pipe, and a cylinder of maximum diameter may be used. A saving of pipe thus is effected, but the cylinder can not be removed as easily as when hung with the drop pipe, nor can it be lowered beyond the casing, often desirable where a well is in rock that stands without lining. Where a drop pipe is used it is a great convenience to the farmer to have it of such size that the plunger can be pulled up for the replacement of cup leathers

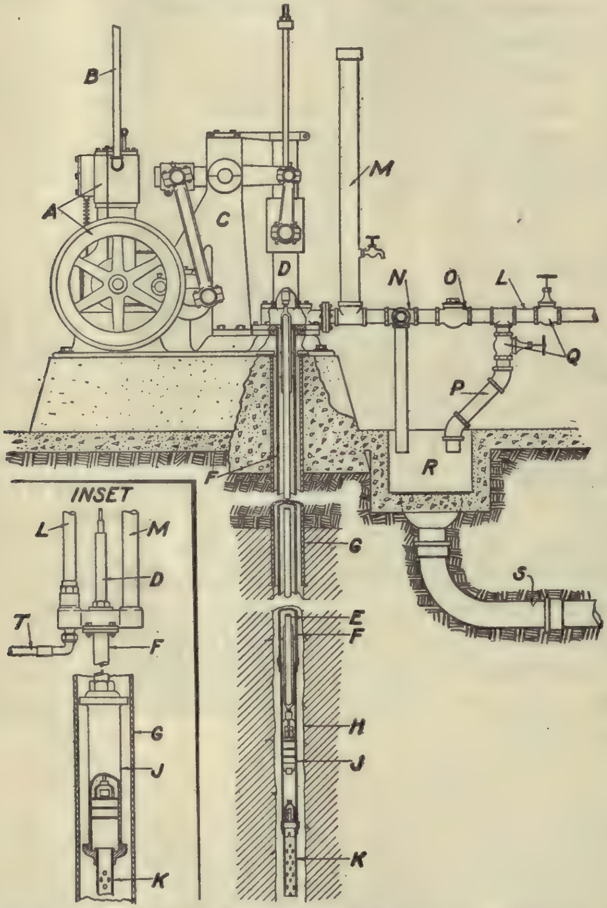

FIG. 37.—Pumping unit, consisting of a single-acting deep-well pump and 2-horsepower gasoline engine. *A*, Engine; *B*, exhaust above roof; *C*, working head; *D*, differential or upper cylinder; *E*, sucker rod; *F*, drop or column pipe; *G*, well casing; *H*, well in rock, uncased; *J*, lower cylinder; *K*, strainer; *L*, 1½-inch discharge pipe; *M*, air chamber; *N*, relief valve; *O*, check valve; *P*, waste and blow-off; *Q*, 1½-inch gate valve; *R*, sump in floor; *S*, 4-inch drain. Not including the well itself, an average installation as illustrated costs about $400. Inset shows details of a deep-well pump suitable for hand or windmill operation. *L*, Surface discharge pipe; *T*, underground discharge pipe; other letters refer as above.

or other repairs. This is true particularly when the length of the drop pipe exceeds 75 or 100 feet. Pump or sucker rods are made of wood, steel or iron pipe, or steel rod. They come in lengths of 10 to 20 feet, and the joints should be made securely. Where a double-acting cylinder is used, in order to keep the pump rod in true alignment some type of guide coupling at intervals of 10 to 15 feet is used. The guide couplings may be carried on the pump rod. The same purpose is gained sometimes by using couplings having a center guide on the drop pipe. In all cases pump-rod joints should come well above the joints in the drop pipe. A hole should be provided in the roof of the building to facilitate the handling of rods and drop pipe.

Usually deep-well farm pumps are single acting; that is, water is lifted and forced on the upward stroke. When operating thus against an elevated reservoir or a hydro-pneumatic (water-air) tank, a heavy variable load is placed upon all working parts. A differential plunger, carried by the pump rod and located in or near the working head, is employed to divide the work between the up and down strokes. In this way all or part (depending on the relative size of the two plungers) of the water lifted to the surface by the lower plunger is forced to the delivery pipe by the down stroke of the differential plunger. Figure 37 shows a deep-well pump driven by a gasoline engine, both mounted on one base.

In all installations the size of the pumping cylinder must be determined from the size, depth, and yielding power of the well, the quantity of water required, and the available power. Deep wells and hand and windmill outfits take the smaller cylinders. The following table shows the capacity [1] of pumps per stroke for one single-acting cylinder.

Capacity of pumps.[1]

Diameter of cylinder in inches.	Length of stroke in inches.								
	2	3	4	5	6	7	8	10	12
	Capacity per stroke in gallons.								
1	0.007	0.010	0.014	0.017	0.020	0.024	0.027	0.034	0.041
1¼	.011	.016	.021	.027	.032	.037	.042	.053	.064
1½	.015	.023	.031	.038	.046	.054	.061	.077	.092
1¾	.021	.031	.042	.052	.062	.073	.083	.104	.125
2	.027	.041	.054	.068	.082	.095	.109	.136	.163
2¼	.034	.052	.069	.086	.103	.120	.138	.172	.207
2½	.042	.064	.085	.106	.127	.149	.170	.212	.255
2¾	.051	.077	.103	.128	.154	.180	.206	.257	.308
3	.061	.092	.122	.153	.184	.214	.245	.306	.367
3¼	.072	.108	.144	.179	.216	.251	.287	.359	.431
3½	.083	.125	.167	.208	.250	.291	.333	.416	.500
3¾	.096	.143	.191	.239	.287	.335	.383	.478	.574
4	.109	.163	.218	.272	.326	.381	.435	.544	.653
4½	.138	.206	.275	.344	.413	.482	.551	.688	.826
5	.170	.255	.340	.425	.510	.595	.680	.850	1.020
5½	.206	.308	.411	.514	.617	.720	.823	1.028	1.234
6	.245	.367	.490	.612	.734	.857	.979	1.224	1.469

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[1] Plunger displacement. No allowance for slip of water past valves. For double-acting cylinders multiply by two. For a longer stroke than shown in the table add the capacities of two shorter strokes to make the required length of stroke.

In selecting a pump the following information should be known: (1) The kind of well, inside diameter, depth to bottom, depth cased, depth to water level both at rest and when pumping (see Wells, p. 26), and the maximum yield. (2) The maximum quantity of water required at buildings, gallons per hour or day. (3) Distance from well to proposed location of pump and the vertical height between these points. (4) Distance from pump to reservoir or tank, and the vertical height between these points. (5) Kind of power, whether hand, windmill, gasoline or oil engine, or electric motor, and desired method of transmitting the power.

The table on the following page shows trade data on pumping units of the suction-lift type and the deep-well type. Capacities are based on plunger displacement, with no allowance for slippage or other losses.

AIR LIFTS.

Air lifts are useful in raising large quantities of water from deep wells. The essential features of an installation are shown in figure 38. The advantages of the method are simplicity, large capacity, noninterference by cold, grit, or sand, and adaptability to drawing from several wells at one time. On the other hand, air-lift installations are costly, the mechanical efficiency may be low, both the depth and yield of the well must be large, and where the discharge is far horizontally the air tends to slip over the water. In many institutional and public systems air lifts are used to bring water to the surface, after which it is handled with steam pumps.

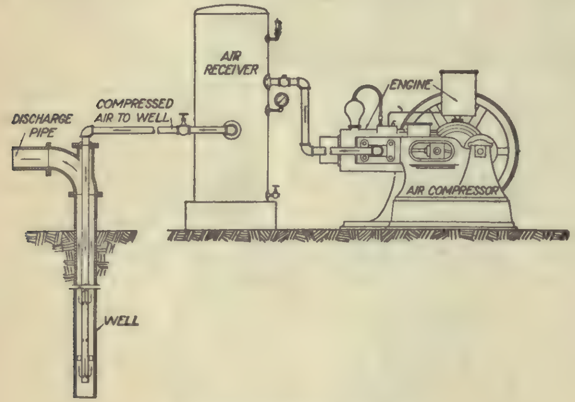

FIG. 38.—Air-lift installation.

Trade data on pumping units (combined double-acting, suction-lift pumps and gasoline engines).

Plunger.		Diameter of pipes.		Revolutions per minute.	Capacity.		Maximum working pressure.		Engine.				Floor space.	Shipping weight.
									Cylinder.		Revolutions per minute.	Horsepower.		
Diameter.	Stroke.	Suction.	Discharge.		Per minute.	Per hour.			Diameter.	Stroke.				
Inches.	*Inches.*	*Inches.*	*Inches.*		*Gallons.*	*Gallons.*	*Pounds.*		*Inches.*	*Inches.*			*Inches.*	*Pounds.*
2	4	1¼	1	50	5.4	324		125	3½	3½	500	1	28 x 30	500
2¾	4	1¼	1¼	50	10.3	618		60	3½	3½	500	1	28 x 30	500
2½	4½	1½	1¼	54	10.3	618		150	4	5	450	2	30 x 46	700
3¼	4½	1½	1¼	54	17.4	1,044		90	4	5	450	2	30 x 46	700
(Combined single-acting, deep-well pumps and gasoline engines.)														
2	6	[1] 1¼	1	40	3.3	198	[2] 100	[3] 138	3	3½	500	1	16 x 36	500
2½	6	[1] 1¼	1	40	5.1	306	[2] 75	[3] 138	3	3½	500	1	16 x 36	500
3	6	[1] 1½	1	40	7.4	444	[2] 50	[3] 138	3	3½	500	1	16 x 36	500
3¼	10	[1] 3½	1½	35	12.6	756	[2] 150	[3] 208	4	5½	450	2	32 x 44	1,000
3¾	10	[1] 4	1½	35	16.7	1,002	[2] 75	[3] 208	4	5½	450	2	32 x 44	1,000
2¼	16	[1] 2½	2	36	9.9	594	[2] 150	[3] 230	....	....	....	2	....	....
2¾	16	[1] 3	2	36	14.8	888	[2] 100	[3] 173	....	....	....	2	....	....
3¾	18	[1] 4	2½	30	25.8	1,548	[2] 150	[3] 208	5	7	375	4	42 x 60	1,800
4¾	18	[1] 5	2½	30	41.4	2,484	[2] 75	[3] 208	5	7	375	4	42 x 60	1,800

[1] Drop pipe.

[2] Depth of well in feet.

[3] Maximum lift above well in feet.

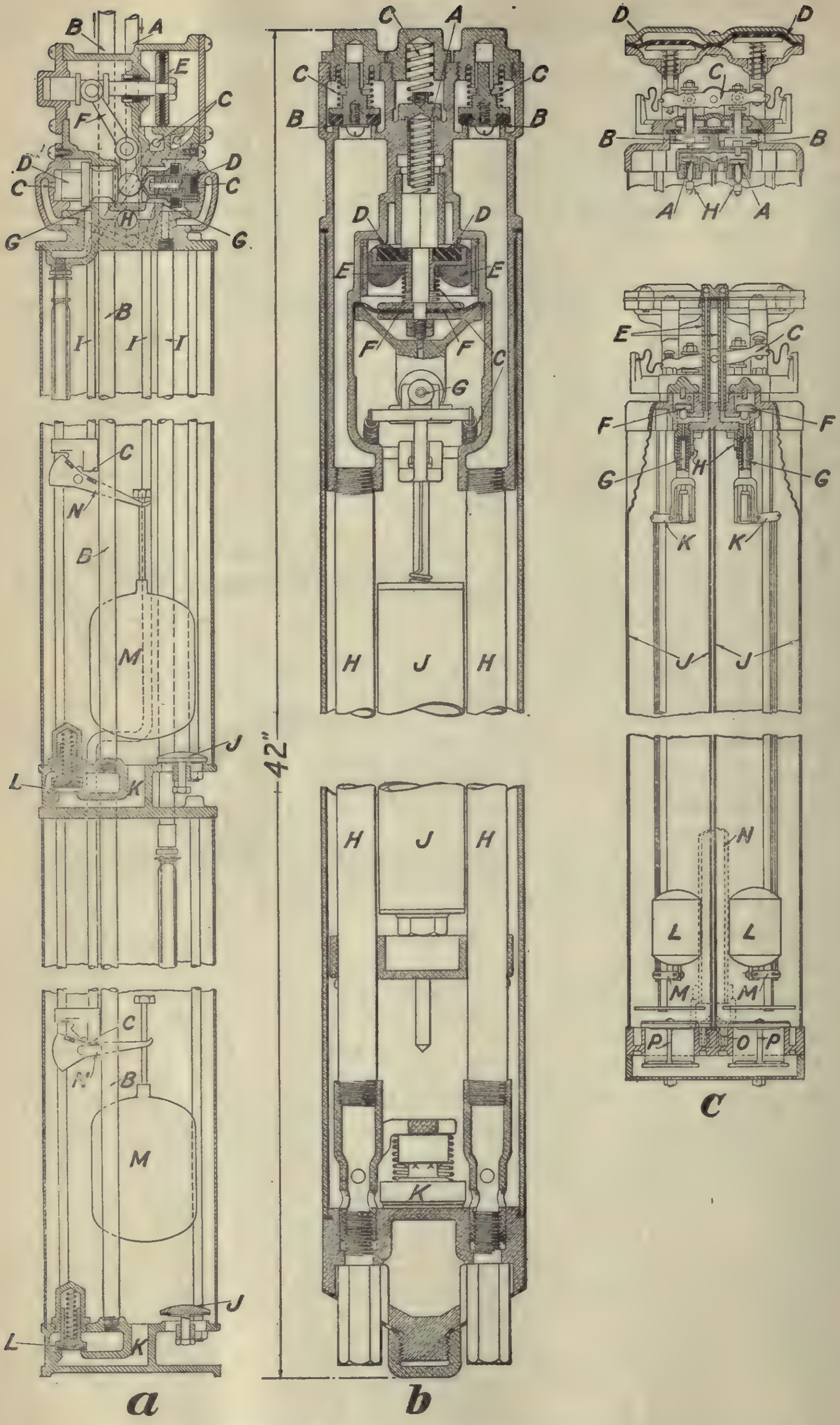

FIG. 39.—Three types of air-displacement pump.

(*a*) *A*, Air-inlet pipe; *B*, water-discharge pipe; *C*, air port; *D*, air valve; *E*, air piston; *F*, rocker arm; *G*, exhaust port; *H*, air discharge; *I*, air pipe; *J*, water-inlet valve; *K*, water port; *L*, check valve; *M*, float; *N*, lever arm.

(*b*) *A*, Air-inlet valve; *B*, water-discharge valve; *C*, springs; *D*, exhaust valve; *E*, screen; *F*, diaphragm; *G*, reversing valve; *H*, water-discharge pipe; *J*, water motor; *K*, water-inlet valve.

(*c*) *A*, Air-inlet valve; *B*, air-exhaust valve; *C*, shifting lever; *D*, diaphragm; *E*, air tube; *F*, diaphragm release valve; *G*, air-controlling valve; *H*, lifting bar; *J*, water cylinder; *K*, controlling-valve lever; *L*, float; *M*, float lever; *N*, water-discharge pipe; *O*, water-discharge valve; *P*, water-inlet valve.

AIR-DISPLACEMENT PUMPS.

Pumping by means of compressed air is very old, but the systems in use prior to 1909 required the air supply to be turned on or shut off according to whether water was or was not needed. Based on a patent granted in 1909, a two-cylinder, air-displacement pump submerged in the water supply and controlled by the opening and closing of a faucet was devised. The cylinders side by side filled and discharged by admitting compressed air to and exhausting it from each chamber alternately. The shifting of the air pressure from one cylinder to the other was effected by an automatic valve mechanism at the top of the pump. Each cylinder had four valve openings, two for inlet and outlet of water and two for inlet and outlet of air. Pumps of the type described, particularly those of galvanized-iron construction, and installed under conditions none too favorable, were often a source of trouble. Among the troubles were racing of the pump when the water supply gave out, worn and leaky valves because of sand and sediment in the water, corrosion of the working parts, and their failure from various minor causes to function properly.

The essential parts of an installation are an air-displacement pump, an air compressor, an air-storage tank, an engine or motor, together with air and water pipes, and minor attachments. Air is piped from the air tank to the pump, and water is piped from the pump to the faucets. The pump operates only when water is used, starting whenever a faucet is opened and continuing until all faucets are closed. Three types of all-brass and bronze, air-displacement pumps are shown in figure 39 (*a*, *b*, and *c*). The outer barrels are removed to show the interior parts. Figure 40 shows the essentials of a complete installation. The mechanical equipment shown costs about $450. Freight, installing, concrete work and well are additional.

The chief advantage of air-displacement pumps is that water may be taken from ordinary depth or lateral distance or from several sources with one power outfit and delivered direct from well to faucet. The power plant may be located wherever convenient, and as many pumps may be used as there are sources for supplying water. Both hard and soft water may be delivered by using two pumps and the necessary piping system. Air-displacement pumps are not adapted at present to lifts of much over 125 feet or to wells less than 3 inches in diameter, nor can they be used where more water than the well can supply is required within a specified period of time. Air pipes and air-displacement pumps must be tight and remain tight in service and the working parts be maintained in good order.

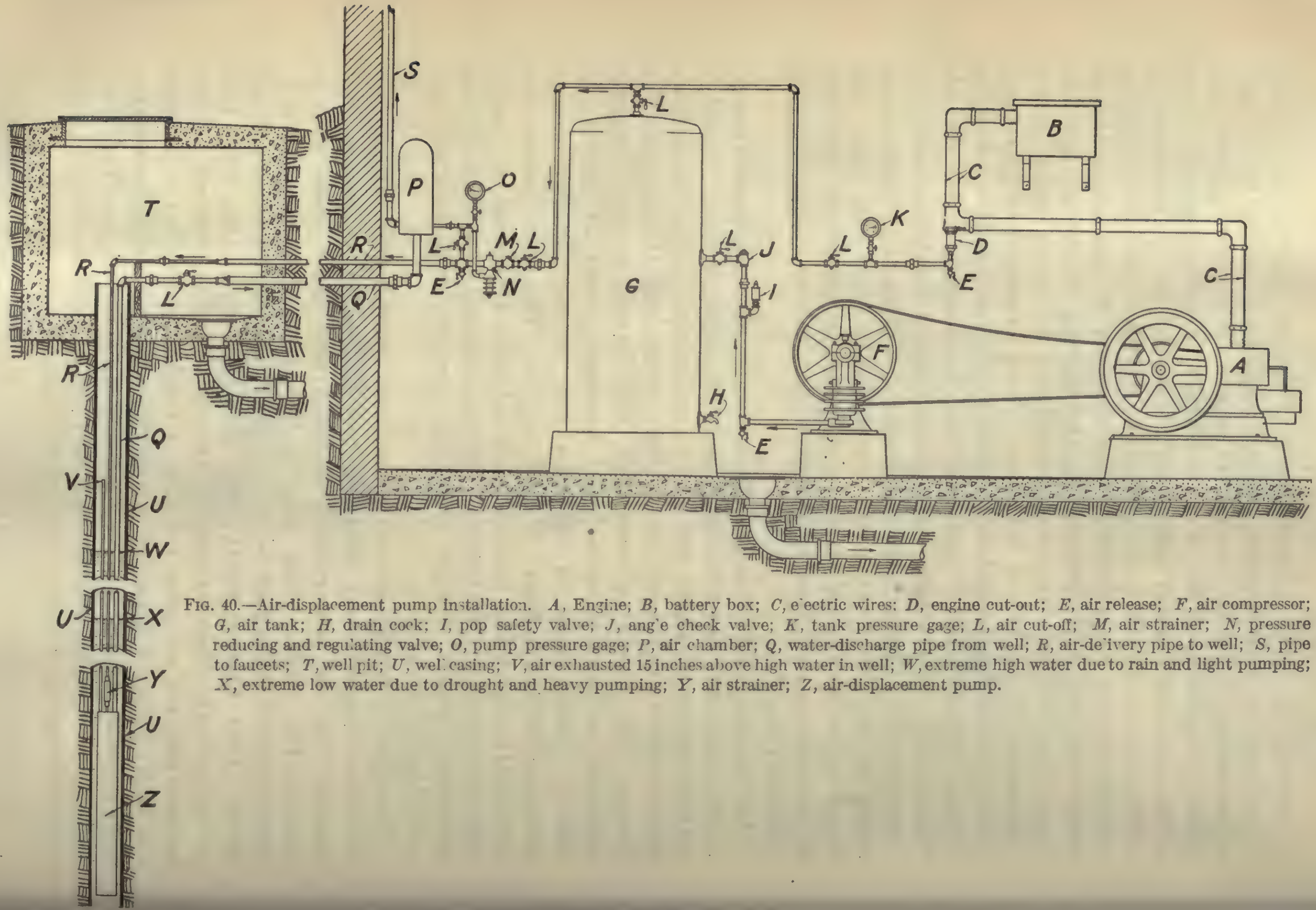

FIG. 40.—Air-displacement pump installation. *A*, Engine; *B*, battery box; *C*, electric wires; *D*, engine cut-out; *E*, air release; *F*, air compressor; *G*, air tank; *H*, drain cock; *I*, pop safety valve; *J*, angle check valve; *K*, tank pressure gage; *L*, air cut-off; *M*, air strainer; *N*, pressure reducing and regulating valve; *O*, pump pressure gage; *P*, air chamber; *Q*, water-discharge pipe from well; *R*, air-delivery pipe to well; *S*, pipe to faucets; *T*, well pit; *U*, well casing; *V*, air exhausted 15 inches above high water in well; *W*, extreme high water due to rain and light pumping; *X*, extreme low water due to drought and heavy pumping; *Y*, air strainer; *Z*, air-displacement pump.

POWER.

The theoretical horsepower necessary to raise water is found by multiplying the gallons pumped in one minute by the total lift including friction (see Friction Loss and Pumping Head, p. 43) in both suction and discharge pipes and then dividing the product by 4,000. The horsepower, as computed, should be multiplied by from 2 to 2½ to overcome losses in the pump and machinery and still provide a reserve of power. Ordinarily, 1 to 2 horsepower engines are sufficient for farm pumping, but it always is safest to compute the amount of power needed.

The latter multiplier (4) should be used where the pump has less capacity than about 30 gallons a minute and is driven by an internal combustion engine or electric motor. Two (2) may be used as a multiplier in large installations or those operated by steam.

Water may be raised by hand, windmill, hydraulic ram, (see Hydraulic Rams, p. 37) steam, hot air, gas, gasoline or other internal combustion engine, and electric motor. Hand power is the readiest applied but is unsuited to large supplies or high lifts. Windmills are used extensively and may be arranged to start and stop automatically according to the height or pressure of the tank supply. Windmills are subject to much wear and tear, are liable to become noisy, and are useless during calms. Experiments[1] at Cheyenne, Wyo., for the months April to September, inclusive, 1904 to 1908, indicate that the most desirable wind velocities for pumping, say 10 to 20 miles per hour, can be expected in that locality only about 28 per cent of the time. With this explanation and caution, trade data on the approximate pumping capacity of windmills in a wind of favorable velocity are given.

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[1] The Use of Windmills in Irrigation in the Semiarid West, U. S. Department of Agriculture Farmers' Bulletin 866.

Trade data on pumping capacity of windmills.

Diameter of wheel.	Length of stroke.	Height water is raised in feet.							
		25		50		75		100	
		Diameter cylinder.	Discharge per hour.	Diameter cylinder.	Discharge per hour.	Diameter cylinder.	Discharge per hour.	Diameter cylinder.	Discharge per hour.
Feet.	*Inches.*	*Inches.*	*Gallons.*	*Inches.*	*Gallons.*	*Inches.*	*Gallons.*	*Inches.*	*Gallons.*
8	6	4	782	3	441	2	307	2¼	247
8	8	3½	799	2½	408	2¼	331	2	261
10	6	5	1,071	4	684	3½	522	3¼	451
10	8	4½	1,157	3½	699	3	514	2¾	432
12	8	6	1,762	5	1,224	4½	991	3½	599
12	10	6	2,203	4¾	1,610	4	979	3½	750
12	12	6	2,644	4½	1,486	4	1,371	3¼	775
14	10	6	1,836	5¾	1,686	4½	1,036	4	816
14	12	6	2,203	5	1,530	4	979	3½	749
16	12	8	3,133	8	3,133	6	2,203	6	2,203
16	16	8¾	4,996	7¼	3,920	6	2,349	5	1,632

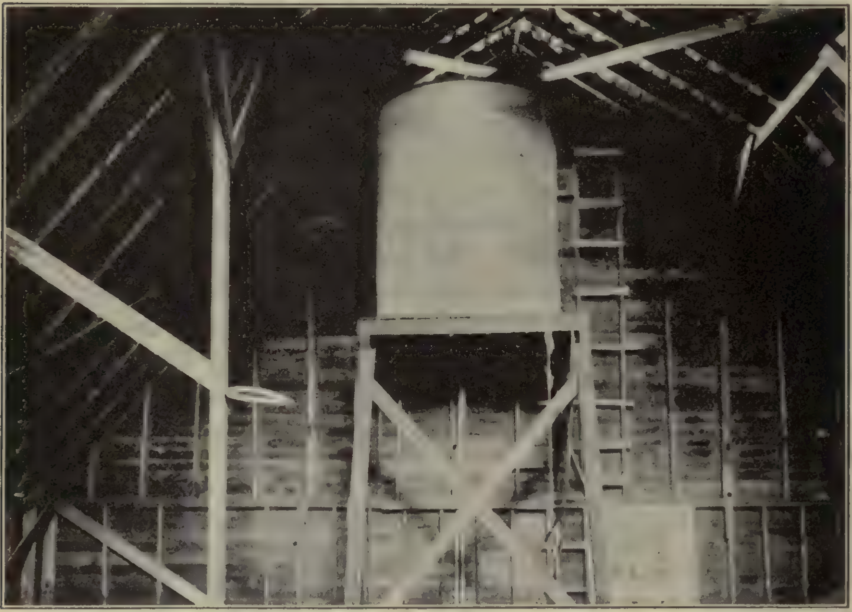

FIG. 41.—Galvanized-iron tank in barn loft, Salina, Kans. Notice the bulge caused by ice near the top.

Gasoline and oil engines are well adapted to farm pumping and may be equipped to stop at any desired pressure in the tank supply. The use of electricity for pumping is increasing rapidly. The method is clean, quiet, and convenient, and starting and stopping a distant pump by throwing a switch may be a reality wherever transmission lines are so near as to make this power available. Electric motors may be had in small sizes and low powers and may be arranged to start and stop automatically with changes in the tank pressure.

STORAGE OF WATER.

ELEVATED TANKS.

Water may be stored in wood, steel, iron, or masonry tanks. To secure gravity delivery, the tank must be elevated above all faucets. With ordinary sizes of pipe, less than 20 feet elevation (static head) does not give satisfactory flow at the faucet. If the delivery pipe be long, the head should be made more than 20 feet or the size of the pipe be increased. (See Friction Loss and Pumping Head, p. 43). The first three kinds of tanks mentioned are located usually in the attic, barn loft, or upon wood or steel trestles or masonry towers. A masonry tank may be placed upon a silo, hill, artificial knoll, or masonry tower. Tanks placed in attics, barn lofts, and upon light trestles are unsatisfactory. The objections relate to insecurity and leakage, lack of pressure, and unwholesomeness of the water in summer and freezing in winter. Wherever possible, masonry tanks, preferably concrete, should be used, and if placed underground upon a hill, trouble with frost will be avoided, the temperature of the water will be agreeable throughout the year, and a simple, certain, and permanent service will be obtained. Tanks should be of suffi-

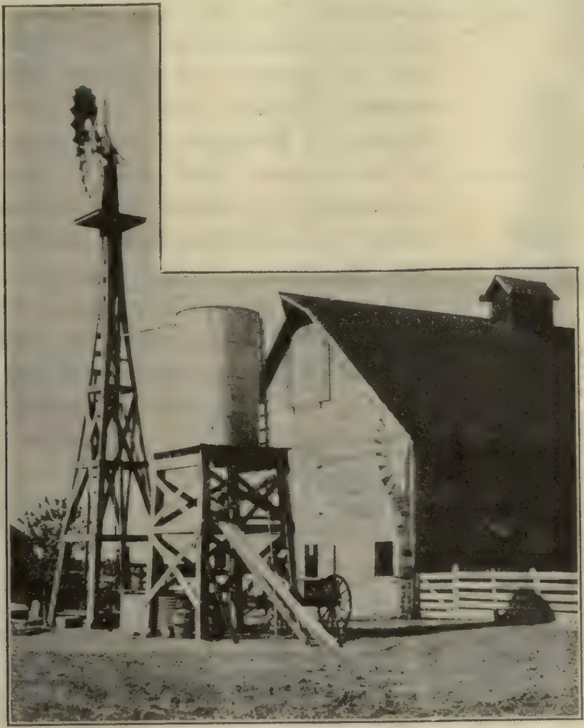

FIG. 42.—Galvanized-iron tank on timber trestle, Herington, Kans. Tank is not used in winter and is unsightly.

cient size to hold at least two days' requirements. For windmill supplies the requirements of a week or more may be needed at times. For emptying and cleaning, tanks should be provided with a waste pipe and valve and without fail should be covered tightly to exclude heat, cold, dust, vermin, and sunlight. When exposed to light, ground and filtered water are very liable to develop growths which impart objectionable odor or taste.

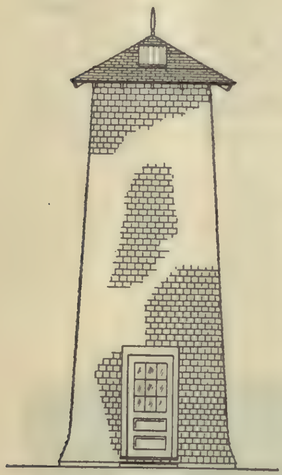

FIG. 43.—A simple frame tower would add to the protection and appearance of the tank shown in fig. 42.

Figures 41 and 42 show galvanized-iron tanks upon farms in Kansas. The first, plainly showing the bulge caused by ice near the top, is located in a barn loft at Salina, and the second is on a timber trestle at Herington. Neither tank is used in winter. Figure 43 illustrates how the unsightliness of the outdoor tank may be eliminated by inclosure in a simple frame tower. If the tower be built with sawdust-filled walls, as was the house shown in figure 27, an excellent cooling and milk room, as well as protection from frost, may be secured. The illustration on the title-page shows a concrete reservoir with wooden roof upon a large dairy farm at Roanoke, Va. The reservoir is 14 feet in diameter and 16 feet deep, and the 8-inch walls are not reinforced with steel. It is situated on a hill about 1,000 feet from the well and 1,900 feet from the buildings. Water is pumped up and delivered to the buildings through 2-inch galvanized pipe. The delivery pipe has a fall of about 35 feet in 1,900 feet and for many years has given sure and satisfactory service. Figure 44 shows a concrete reservoir completely underground. Figure 45 shows a combined reinforced concrete storage tank and cooling room.

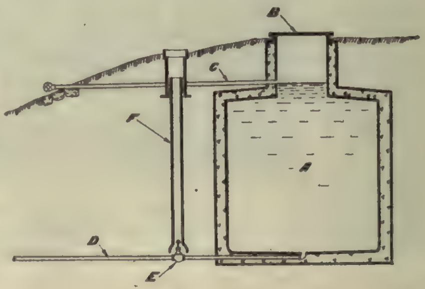

FIG. 44.—Underground concrete reservoir, suitable where high ground is available. *A*, Reservoir; *B*, cast-iron manhole frame and overhanging cover; *C*, screened overflow; *D*, pipe discharge from pump and delivery to buildings; *E*, gate valve; *F*, extension gate box.

HYDROPNEUMATIC TANKS.

Water may be stored and delivered to the faucet by the use of a hydropneumatic (water-air) tank. With this system the tank need not be elevated and usually is conveniently located in a utility room, basement, cellar, or even underground, although the latter situation favors rusting and prevents inspection and painting. Hydropneumatic tanks must be absolutely air-tight, for the principle upon which they operate depends on the expansive force which air when compressed exerts. Air being lighter than water occupies the upper portion of the tank, and it presses with increasing force against the water as either more water or more air are pumped into the tank. For house service, generally the pressure ranges between 20 and 50 pounds per square inch. When air and water are under pressure the latter gradually absorbs the former, and this absorption is the more rapid the higher the pressure. From time to time, therefore, the air supply must be replenished, or the tank becomes waterlogged. Maintenance of the air supply is a vital factor in the successful operation of hydropneumatic systems. Where low pressures are carried a hand air pump used once a month often suffices. It is easier and more convenient, however, to introduce the air with the water when the pump is running. This is accomplished in several ways, such as by using a combined air and water pump, an air compressor, and, in one type of deep-well pump, a combined air inlet and check valve.

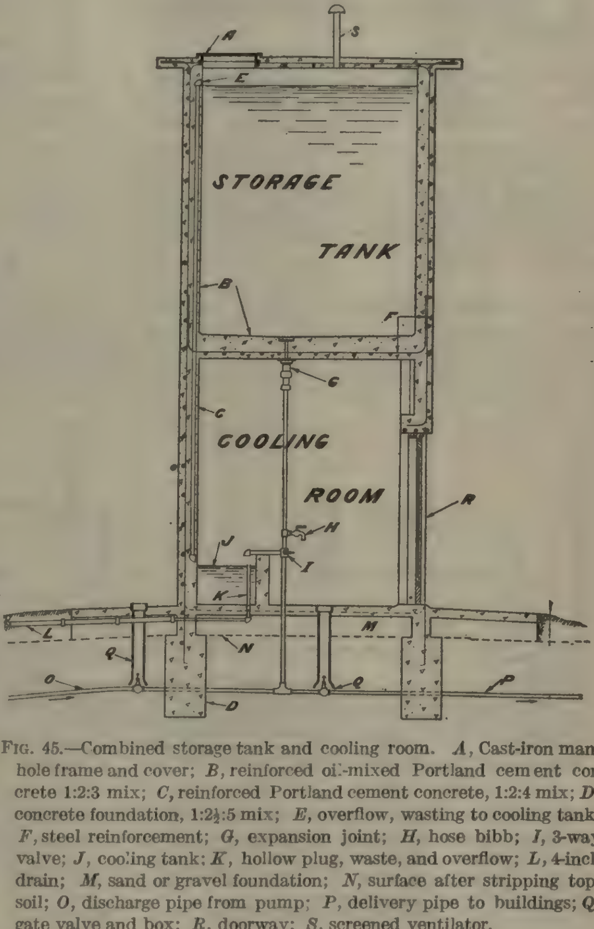

FIG. 45.—Combined storage tank and cooling room. *A*, Cast-iron manhole frame and cover; *B*, reinforced oil-mixed Portland cement concrete 1:2:3 mix; *C*, reinforced Portland cement concrete, 1:2:4 mix; *D*, concrete foundation, 1:2½:5 mix; *E*, overflow, wasting to cooling tank; *F*, steel reinforcement; *G*, expansion joint; *H*, hose bibb; *I*, 3-way valve; *J*, cooling tank; *K*, hollow plug, waste, and overflow; *L*, 4-inch drain; *M*, sand or gravel foundation; *N*, surface after stripping topsoil; *O*, discharge pipe from pump; *P*, delivery pipe to buildings; *Q*, gate valve and box; *R*, doorway; *S*, screened ventilator.

Hydropneumatic tanks are made of steel with either riveted or brazed joints. They may be black or galvanized and be set vertically or horizontally. Vertical tanks require less floor space, but when over 6 feet long a horizontal setting is usually preferred. They may be used in connection with any hand or power force pump, a hydraulic ram, or sometimes even with a flowing well, as shown in figure 46. A typical installation is shown in figure 47. Every outfit should be well constructed, well installed, and well operated. Reliable manufacturers give concise directions as to setting up, testing, repairing, adjusting, and operating their outfits. The farmer should follow the directions faithfully, and if any deficiencies show up, he should notify the manufacturer. Usually, the trouble can be located through corrrespondence and is easily corrected.

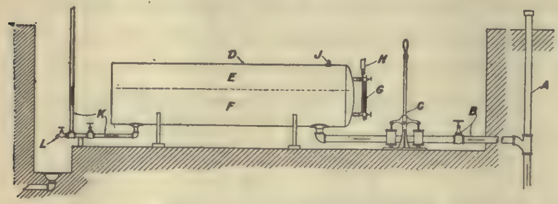

FIG. 46.—Hydropneumatic tank installation suitable for locations having a flowing well or a spring situated slightly higher than the tank. *A*, Flowing well; *B*, 2-inch supply pipe and gate valve; *C*, hand-operated air pump; *D*, tank; *E*, space occupied by air; *F*, space occupied by water; *G*, water gage; *H*, pressure gage; *J*, air cock, to be open when filling the tank with water and closed when pumping in air; *K*, service pipe and gate valve; *L*, blow-off and drain cock. A 500-gallon tank installed, complete, costs on the average about $200.

The table next following gives trade data and approximate cost of good grades of hydropneumatic tanks suitable for working pressures up to 75 pounds per square inch. The water capacity is taken usually as two-thirds of the total capacity, the remaining one-third being occupied by air. Because of conditions imposed by the war the prices are liable not to be close to market quotations.

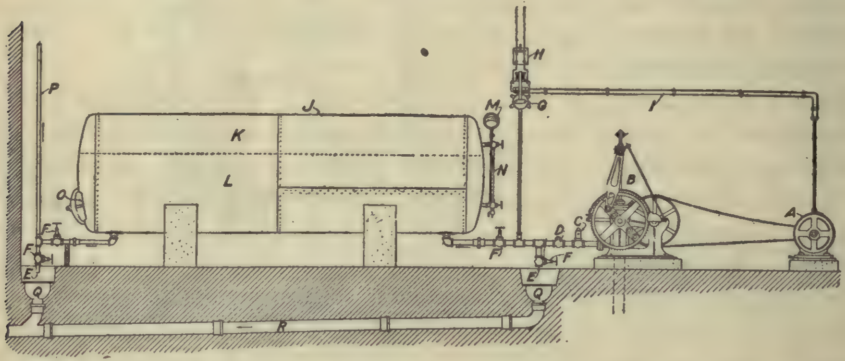

FIG. 47.—Typical hydropneumatic tank installation and working-head belt connected to an electric motor. *A*, Motor; *B*, working head or pumping jack; *C*, relief valve; *D*, check valve; *E*, blow-off and waste; *F*, gate valve; *G*, automatic controller; *H*, line switch; *I*, wires to motor; *J*, tank; *K*, space occupied by air; *L*, space occupied by water; *M*, pressure gage; *N*, water gage; *O*, manhole; *P*, pipe to faucets; *Q*, bell trap; *R*, 4-inch cast-iron drain.

Trade data on hydropneumatic tanks.

Diameter.	Length.	Weight.	Total capacity.	Approximate cost.	Diameter.	Length.	Weight.	Total capacity.	Approximate cost.
Inches.	*Feet.*	*Pounds.*	*Gallons.*	*Dollars.*	*Inches.*	*Feet.*	*Pounds.*	*Gallons.*	*Dollars.*
24	6	370	140	30	42	8	1,420	575	82
24	8	450	190	37	42	10	1,700	720	94
24	10	525	235	42	42	12	1,950	865	107
30	6	560	220	36	42	14	2,200	1,000	116
30	8	680	295	44	48	10	2,070	910	131
30	10	800	365	50	48	12	2,370	1,180	143
30	12	915	440	56	48	14	2,670	1,300	156
36	6	790	315	46	48	16	2,970	1,500	173
36	8	950	420	56	48	18	3,270	1,700	194
36	10	1,120	525	64	48	20	3,570	1,880	209
36	12	1,300	630	71	48	24	4,170	2,260	234
36	14	1,450	735	83					

In order to deliver all the water from a hydropneumatic tank it is necessary to carry an initial or excess air pressure; that is, enough air to give pressure when no water is in the tank. If a tank be located in the cellar or basement, 10 pounds excess air is sufficient to deliver all the water to the second story, but if far removed or far below the house a greater excess may be necessary. The following table shows what fractional part of any tank, either vertically or horizontally set, contains water under varying conditions of gage pressure and excess air pressure.

Amount of water in fractional part of total capacity of any hydropneumatic tank.

Gage pressure.	Excess air in tank in pounds.					Gage pressure.	Excess air in tank in pounds.				
	0	10	15	20	25		0	10	15	20	25
Pounds.						*Pounds.*					
100	0.870	0.783	0.739	0.696	0.652	50	0.769	0.615	0.538	0.462	0.385
95	.864	.773	.727	.682	.636	45	.750	.583	.500	.417	.333
90	.857	.762	.714	.667	.619	40	.727	.545	.455	.364	.273
85	.850	.750	.700	.650	.600	35	.700	.500	.400	.300	.200
80	.842	.737	.684	.632	.579	30	.667	.444	.333	.222	.111
75	.833	.722	.667	.611	.556	25	.625	.375	.250	.125	....
70	.824	.706	.647	.588	.529	20	.571	.286	.143	....	....
65	.812	.687	.625	.562	.500	15	.500	.167	....	....	....
60	.800	.667	.600	.533	.467	10	.400	....	....	....	....
55	.786	.643	.571	.500	.429	5	.250	....	....	....	....

This table has broad application. For example, it shows that if water is pumped into any tank having no initial pressure above that of the atmosphere until the gage shows 5 pounds, the tank will be one-fourth filled with water; at 15 pounds it will be one-half full; at 30 pounds it will be two-thirds full; at 45 pounds it will be three-fourths full; at 60 pounds it will be four-fifths full. Inspection of the table shows also the value of excess air in a tank. If 25 per cent of the total capacity be drawn from a tank three-fourths filled with water and having a gage pressure of 45 pounds, the pressure will be reduced to 15 pounds. Had the tank contained 10 pounds excess air, 42 per cent of the total capacity ($0.583-0.167=0.416$) could have been drawn between pressures 45 and 15 pounds. Under the latter condition, therefore, the working capacity of the tank would have been nearly doubled, the exact ratio being as 42 to 25.

PIPES.

Water pipes of wood, lead, brass, black and galvanized (zinc coated) wrought iron, steel, tin, cement-lined iron and steel, and cast iron have been used at various times and places. The use of wooden pipes is confined mainly to the West and to sizes above 2 inches. Lead, brass, or lead-lined pipes should not be used for conveying water for drinking and cooking. This caution applies with especial force to lead pipe and to cases where the water is soft and contains much free carbonic acid and oxygen or stands for some time in the pipes. Different waters and soils vary greatly in their power to attack and corrode metals. In general, alkaline and cinder soils promote corrosion faster than do clay soils and very much faster than do sands and gravels. Steel pipes corrode more rapidly than wrought iron pipes. Galvanizing does not always add greatly to the life of the pipe. But galvanized pipe is cleaner than black pipe and is generally preferred. Tin and tin-lined pipes have been used considerably and are durable and safe. Cast-iron pipe is preferred for 4-inch or larger sizes, and ordinarily, if well coated, its life is very great but may be shortened by alkaline soils.

One of the best and most practical linings for keeping the bore of iron pipes free from rust is cement. On the writer's desk is a piece of 1-inch wrought-iron pipe lined with cement to a three-fourths-inch bore and taken from a line laid in Massachusetts in 1872. Although the pipe was in use more than 40 years, the bore is unrestricted and in perfect condition. The exterior is badly pitted and corroded. New cement-lined pipe of the size above mentioned was worth about 9 cents per foot in October, 1915. The process of lining is simple, and if understood the work can be done rapidly and well with the ordinary labor of the farm. The work does, however, require some special appliances and must be handled with care and judgment. One farmer hardly would be warranted in attempting to cement-line his pipe, unless a large quantity were needed. It would be entirely practicable, however, for two or three to combine and line the pipe for a neighborhood or locality. Essentially, the process consists in forcing with a press a quantity of neat or at least very rich Portland cement mortar into single lengths of pipe and then boring out the mortar while soft by pulling through a wire to which is attached a pointed brass pipe having an exterior diameter the same as that of the bore desired. The lining in small wrought pipes usually is about one-eighth of an inch thick.

All water pipes should be laid below frost, should be tested under pressure before back filling the trench, and should be flushed out before the installation has been put to actual use. Pipes through cellar walls are particularly subject to rust, and it is prudent to embed them in cement at that point. At points liable to be caught by frost, pipes may be boxed and surrounded with pea or nut-size coke, ground cork, felt, mineral wool, or other nonconducting material. Sawdust, excelsior, or straw may be used for this purpose, but are perishable and introduce more or less fire hazzard.

FIRE PREVENTION.

A high percentage of farm fires is due to carelessness and is preventable. The more common preventable causes of fire are carelessness in handling matches, pipes, and cigarettes, children playing with fire, accumulations of rubbish, litter and greasy rags, defective and sooty chimneys and flues, unchecked and overheated stoves and furnaces, sparks from grates and chimneys, hot ashes against wood, ignition of oil and hot grease, drying green wood in ovens, thawing out frozen water pipes by flame, defective electric wiring, and failure to turn off the current after using various small electrical devices. In short, carelessness is the great fire hazard, and the watchword upon every farm should be prevention first and protection second.[1]

To fight a well-ignited fire successfully requires more water and higher pressure than ordinarily are obtained with farm water systems. A small ragged stream directed at a large fire is practically of no avail on account of its dispersion by heat, and it may happen easily that no water reaches the desired point. Other practical difficulties relate to frozen pipe lines, shortage or defects in the hose, misplaced nozzles, and lack of experience in the skillful use of the equipment when the time comes to fight fire. These matters are, of course, fully understood and recognized by underwriting associations, and farm water systems are not, as far as the writer knows, given credit in insurance ratings. To obtain such credit, the following probably would be necessary: A gravity supply capable of furnishing two streams of 250 gallons a minute each for at least one hour at a pressure sufficient to cover all major buildings, together with hydrants at such locations and hose in such quantities as would enable the two streams to be applied to such buildings, and sufficient continuous attendance to operate these appliances. Although farm water systems seldom can comply with this specification, they may be of great value if a fire be discovered in its incipient stage, and it undoubtedly is wise where a pressure system is installed to provide a liberal number of hose connections, the preferable locations being the engine room, house basement, kitchen, and second floor. An automatic sprinkler system is a great aid in preventing serious fire. Such installation in large, costly farm buildings may be a wise step, adding greatly as it does, to the value of the plant considered as a going business.

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[1] Methods of preventing and fighting fire are described fully in Farmers' Bulletin 904, United States Department of Agriculture, "Fire Prevention and Fire Fighting on the Farm," and in Circular 75, "Safety for the Household," issued by the Bureau of Standards, United States Department of Commerce,

WATER SOFTENING.

An excess of salts of lime, magnesia, and iron dissolved in water makes it hard, and therefore undesirable for drinking and cooking, ineffective and costly for cleaning and laundry purposes, and destructive to kettles, pipes, and boilers. Water softening is the process of removing the dissolved minerals mentioned above. It is a chemical process and therefore is distinct from the removal of floating or settled solids such as silt or mud. Filtration alone will not soften water. Hardness caused by lime, magnesia, and iron carbonates held in solution by carbonic acid may be removed in part by boiling the water. Hardness caused by the sulphates, chlorides, and nitrates of lime, magnesia, and iron can not be removed by boiling. Taken together, these compounds constitute the principal scale-forming ingredients found in hard water. Such water may be treated chemically to form a more or less insoluble precipitate which may be removed by sedimentation (subsidence) followed by filtration.

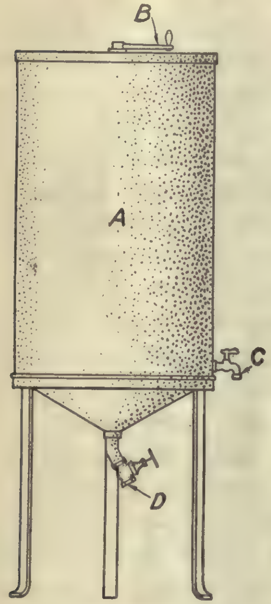

FIG. 48.—Household water softener. *A*, Cylindrical tank; *B*, crank attached to a vertical shaft carrying blades or paddles to secure thorough mixing of the chemicals with the raw water; *C*, faucet for drawing softened water; *D*, valve for drawing off the settled solids (mud).

Another group of impurities found in alkaline waters are sodium chloride (common salt), sodium sulphate (Glauber's salts), and sodium carbonate (soda-ash). The first two constitute what is known as white alkali, and the third constitutes black alkali. Unless present in large quantities, these compounds are non-scale forming, but their presence in more than normal amounts unfits water for domestic consumption. The sodium salts are very soluble in water, nor can they be precipitated by heat or chemicals or removed by filtration. Their successful removal has been accomplished only by distillation.

Two types of water softener are used, the intermittent and the continuous. In the intermittent a definite quantity of raw water is treated with a fixed amount of such chemical reagents as analysis of the water indicates are needed. Lime, soda-ash, trisodium phosphate, barium hydrate, and barium chloride are among the reagents used.

Figure 48 shows a simple household water softener of the intermittent type. It may be used for preparing water for laundry purposes, but is not suitable for drinking or other potable waters. Softeners of the continuous type, because of their large capacity and cost and the close attention they require, have been little used upon farms. Individuals who can afford such softeners or farmers combining to install them can, if the necessary attention be given the installations, obtain very satisfactory results. It should be remembered, however, that, although a water softener may remove most or even all of scale-forming ingredients, the alkaline salts are not removed and, in fact, are likely to be increased.

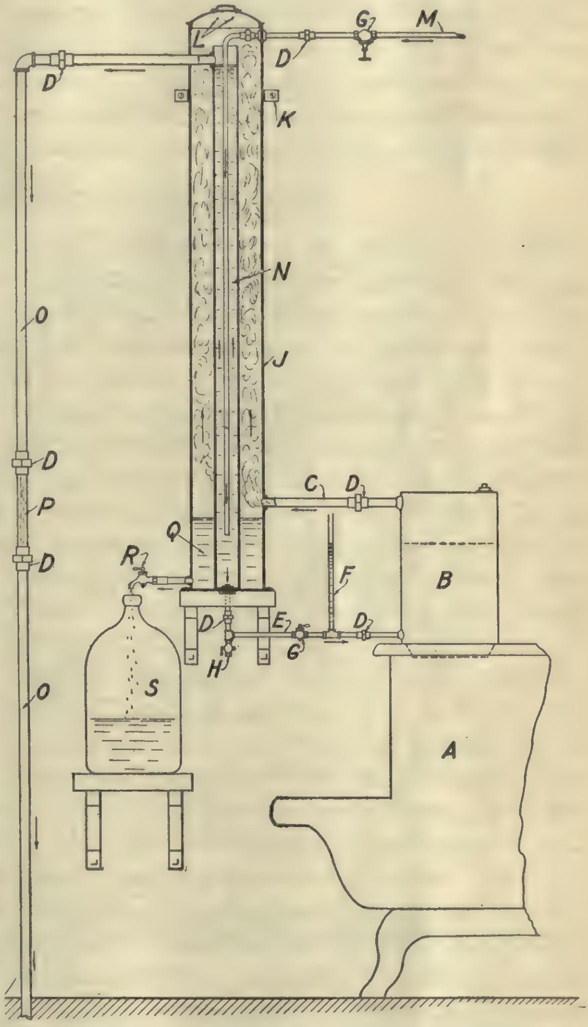

Fig. 49. Household still.—*A*, Stove; *B*, boiler; *C*, steam pipe; *D*, union; *E*, raw-water feed pipe; *F* water gage (glass tube open at top); *G*, valve; *H*, drain cock; *J*, condenser; *K*, strap; *L*, vents in cover; *M*, raw-water supply pipe; *N*, cooling tank; *O*, waste pipe; *P*, observation glass; *Q*, distilled water; *R*, cock for drawing distilled water; *S*, glass vessel.

STILLS.

Water containing dissolved minerals or other impurities may be softened and purified completely by distillation, a process involving boiling the water and condensing the steam. Objections to distillation relate to the slowness, tediousness, and cost of the process, the cost of stills, the flat taste of distilled water, and the tendency of volatile products to pass through with the steam and be absorbed by the distillate. These objections, together with the high cost of tin, copper, and brass, have tended to prevent the production and use of good, low-cost stills adapted to farm use. Small stills are made to utilize the heat of oil, gas, and coal stoves, gasoline torches, electric heaters, and steam pipes. A household still of simple type is shown in figure 49. A still capable of giving fair results may be constructed by a good village tinsmith. All parts in contact with water or steam should be pure tin or heavily lined with tin, and the distilled water should be kept in tightly-stoppered bottles or a glass vessel. An arrangement of pipes whereby a constant flow of cold water is received in and escapes from the condenser adds greatly to the capacity and ease of operation.

INSIDE PIPES AND FIXTURES.

Figure 50 shows an arrangement of pipes and fixtures in a well-equipped farm home. The cold-water pipes are shown in outline and the hot-water pipes in black. The size of the pipes may be varied according to the pressure from the supply tank and the demands for water at particular points. Under average conditions, say where the pressure is from 20 to 40 pounds, the sizes shown in the figure are ample. All pipe and fixtures should be durable and so installed that inspection, control, drainage, and repairs can be made easily. The fixtures should be of simple, approved patterns. The main supply pipe should have a stop and waste cock just inside the cellar wall. In cold climates and in houses not well heated, pipes should be kept from outside walls. (See Pipes, p. 62, for methods of protection from frost.)

Water pipes not seen are usually of galvanized iron. Pipes exposed to view in the kitchen and laundry look better if made of brass. Nickel plating further adds to the appearance of bathrooms or other places where plumbing is seen. Cold-water pipes, because of the condensation of moisture from the air and the drip on floors, should never run along the ceilings of rooms. All pipes should slope slightly so that the entire hot and cold water systems may be drained at low-situated faucets and at the stop and waste cock in the cellar.

Range boilers may be galvanized iron or copper and are made in various sizes and strengths. Galvanized boilers may be set vertically or horizontally. They usually are riveted, have capacities between 20 and 190 gallons, and sometimes are fitted with a steam coil so that other heat than the kitchen range may be utilized. Copper boilers are seamless or have brazed joints, may be tin lined, and often have inside ribs to strengthen and stiffen them. Capacities run from 30 to 250 or more gallons. Because of better appearance and less liability to leakage and corrosion, copper boilers are preferred to galvanized-iron boilers. Formerly a small gravity tank equipped with a ball cock in an upper room or attic was much used in connection with range boilers, and in such cases lightweight

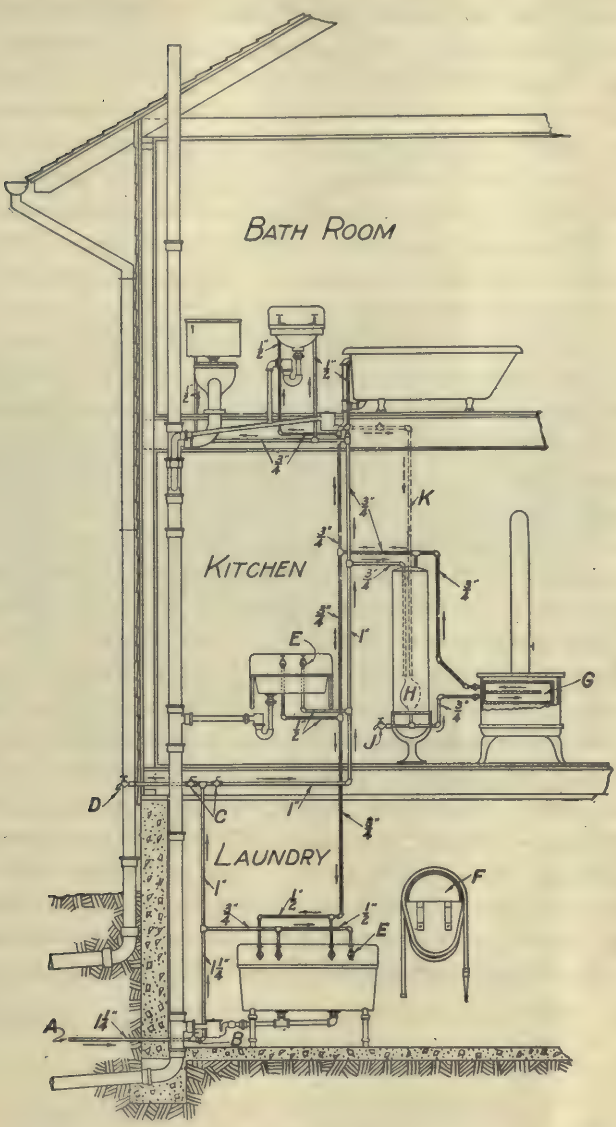

FIG. 50.—An arrangement of pipes and fixtures in a well-plumbed farm house. *A*, Service pipe to house; *B*, stop and waste cock; *C*, stop cock; *D*, sill cock; *E*, hose bibb; *F*, hose and home-made, half-round wooden hose hanger (hanger may be made by nailing lagging to two half-heads of a barrel); *G*, kitchen range and water front; *H*, range boiler; *J*, hose bibb for draining boiler; *K*, return pipe (not absolutely essential, but improves the circulation of hot water and is of particular value where hot-water faucets are located far from the boiler). Prior to 1916 the plumbing installation here shown cost approximately $280. This cost covered all pipes (rain conductor excepted), traps, valves, fittings, fixtures, the stove, and the labor and materials used in installing. The fixtures included a 5-foot enameled-iron bathtub, 20-inch enameled-iron washbasin, vitreous china wash-down water-closet; 30-gallon galvanized-iron boiler, 1-piece enameled-iron sink, 18 inches by 36 inches, and a 2-compartment stone laundry tray. Due to the war-time advance in the cost of labor and materials from $500 to $600 should be allowed for the installation, complete, to-day (March, 1918).

boilers could be used. It is better, however, to have the boiler heavy enough to carry safely the full pressure of the supply tank or reservoir, and such boiler will better resist the corrosion that comes with long use. A suitable capacity of boiler for an average farm or village home is 30 to 40 gallons. With two bathrooms or other large use of hot water the capacity should be increased materially.

Where the winters are severe and water pipes are liable to freeze, one should always assure himself before starting the range fire in the morning that ice has not sealed the water front or its connections. Continuance of the main supply may be ascertained by opening hot and cold-water faucets at the kitchen sink. This procedure, however, does not prove the absence of a freeze-up in the short connections between the range boiler and the water front. To further guard against range-boiler explosions, something that may happen wherever expansion is cut off through closure of a supply-pipe valve or other stoppage, the boiler always should be equipped with a safety valve so arranged that nothing can interfere with its operation.

A word in conclusion: In each instance, before going ahead, study the local conditions. These, finally, must determine the main features of every installation. Were advice to be given in a brief general statement, it would be as follows: Make sure of the purity of the supply. If the supply is a spring or flowing well, deliver to the buildings by gravity, if practicable. Where a well is necessary, use a good, deep, dug or open-end tubular well fed from pure and unfailing sources. Install such type of pumping machinery as best combines simplicity, certainty, capacity, and adaptability. Provide liberal storage capacity, employing if possible an underground concrete reservoir on a near-by hill. Lay galvanized iron or cement-lined delivery pipe of ample size below the reach of frost. Arrange the house piping systems to admit of easy control, drainage, and repair. Use fixtures of simple, durable, yet pleasing patterns.

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CONTROLLING THE CLOVER-FLOWER MIDGE IN THE PACIFIC NORTHWEST

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FARMERS' BULLETIN 942

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. April, 1918

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TINY MAGGOTS in red-clover flowers prevent the seeds from maturing and cause a great reduction in the seed crop. These maggots are the young of a very minute fly known as the clover-flower midge.

The farm practices by which this little pest can be controlled in the Pacific Northwest are, with certain modifications, the same as those followed in the East, namely, close pasturing, early cutting, clipping, and soiling. These measures are explained on pages 10 to 12.

Close pasturing of red clover until late May or early June is an effective means of exterminating the midge. If close pasturing is impracticable, run a mower over the field to clip off the stray heads before starting the seed crop.

Where both hay and seed crops are desired, cut the hay crop by June 1. This will control the midge effectually and prevent infestation. Never put off the cutting beyond the first week in June unless the weather is unfavorable, in which case the crop should be cut just as soon as fair weather returns.

Clipping and soiling red clover during the spring and early summer are equally efficacious methods of exterminating the midge, provided young heads of the seed crop are not allowed to appear before the middle of June.

CONTROLLING THE CLOVER-FLOWER MIDGE IN THE PACIFIC NORTHWEST.

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ESTABLISHMENT AND DISTRIBUTION IN THE PACIFIC NORTHWEST.

THE CLOVER-FLOWER MIDGE[1] (fig. 1), long recognized by the clover-seed growers of the Eastern and Central States as one of their most serious pests, has become established in the Pacific Northwest, and since 1913 has caused alarming reduction in the seed yields. While the insect undoubtedly became established on the Pacific coast a number of years prior to 1913, there is no record of its having been present in sufficient numbers to affect the clover-seed industry seriously.

The midge now occurs throughout Washington and Oregon west of the Cascades wherever red clover is grown, and east of the Cascades in the Yakima and Columbia Valleys of Washington and the Jocko Valley of western Montana. It has not yet been reported from the great seed section of Idaho, or from the coast counties of northern California where red clover is raised to a limited extent.

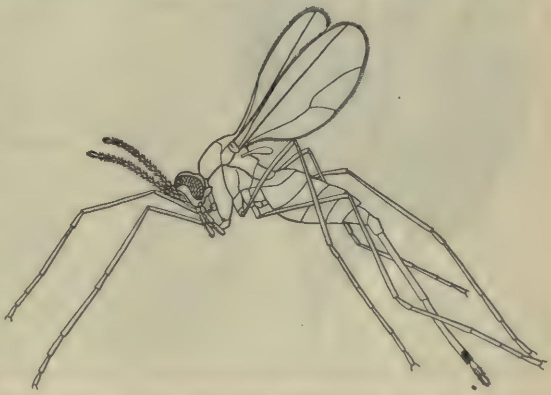

FIG. 1.—The clover-flower midge. Enlarged side view of female fly with scales denuded to show more clearly the structure. Greatly enlarged.

This insect is readily controlled in the East by following certain farm practices, and investigations by the Department of Agriculture have shown that, with certain modifications, these practices can be followed successfully in the Pacific Northwest

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[1] *Dasyneura leguminicola* (Lintner); order Diptera family Cecidomyiidae.

FOOD PLANTS AND NATURE OF INJURY.

Red clover is the chief food plant of the clover-flower midge in Oregon and Washington, as is the case in the States east of the Rocky Mountains. The midge is rarely found on either white or alsike clover and is never present on these plants in sufficient numbers to affect seed production.

The clover-flower midge is injurious only in its larva or maggot stage. As its name implies, it works in the flower (fig. 2), feeding upon those parts which normally would develop into seed. Although one maggot prevents the formation of only a single seed, the insects can make serious inroads on the seed crop when present in great numbers, as they usually are in infested fields.

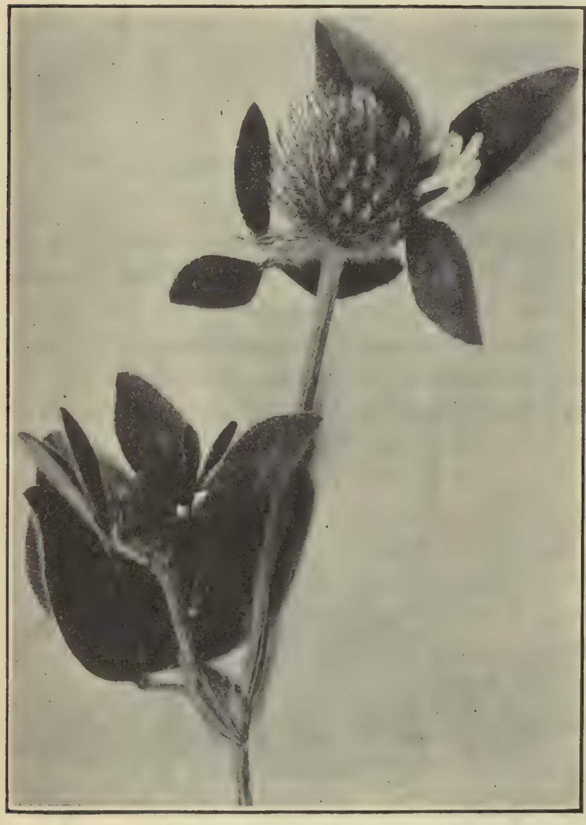


FIG. 2.—Clover heads injured by the clover-flower midge.

The forage value of red clover is not impaired by midge infestation and the insect, therefore, is of economic importance only in seed-growing districts.

SEASONAL HISTORY.

The clover-flower midge, which is a delicate mosquito-like fly, passes the winter as a larva, or maggot, generally in a silken case or cocoon on or slightly below the surface of the ground. Occasionally no cocoons are spun, especially where ample protection is afforded by the débris covering the surface of the soil. The coccoon is very small, oval, and measures approximately one-tenth of an inch in length and one-twentieth of an inch in diameter. It is constructed of a white papery substance of a leathery consistency and is very difficult to recognize in its natural location because of the coating of earth which usually obscures completely the cocoon proper, causing it to resemble a small lump of earth.

With the first warm days of early April a few of the larvæ in the cocoons begin to change to the pupa or resting stage, and by the first of May the greater portion of the brood has either begun to transform or is in the pupa stage. The pupa period during April and May lasts from two to three weeks, depending upon the season. In seasons of an early spring a few midges complete their transformation and emerge as adults by April 21. If the season is late none may be found in the fields before May 5.

The adult fly (fig. 2) is somewhat smaller than a mosquito and of similar delicate and fragile structure. It is strikingly and beautifully marked, the anterior half being black, with hair-fringed dusky wings, and the posterior half, or abdomen, bright vermilion red in fresh specimens. The abdomen of the female is equipped with a long extensible egg-laying tube, or ovipositor, by means of which the eggs are inserted in the young clover heads. The male differs from the female in being more slender and fragile, and the shorter abdomen is equipped with a pair of clasping organs used in mating.

Unless the season is unusually late, by May 5 young clover heads have begun to appear in noticeable numbers and adults are common. The maximum abundance usually is reached between the 18th and the 25th of the month. From this time on there is a gradual decrease in numbers until about the latter part of the first week in June, by which time they have become relatively scarce. Scattered individuals often are found, however, until the latter part of June.

While the foregoing briefly outlines the periods when adult midges may be expected to be on the increase or decrease in a given clover field, it must not be supposed that this increase or decrease is at all uniform. The cool rains of several days' duration which occur at frequent intervals during the month of May cause a temporary sharp decrease in numbers by checking the emergence of new adults, and a corresponding increase in numbers may always be looked for during the fair weather immediately following such rains.

Upon emerging, the females, which are much more plentiful than the males, mate and proceed to the small green clover heads, and in these they lay their eggs. In selecting a place for egg-laying marked preference is shown for young clover heads which are just beginning to appear through the leaf sheath, but the midge if at all numerous frequently will select older heads providing they are still green.

The egg is oval, about three times as long as broad, and barely visible to the naked eye. It is pale yellow at first, but an internal orange spot appears just before hatching. Eggs are found both singly and in clusters, usually stuck to the hairs of the calyx (fig. 4) or to the calyx itself, but not infrequently in clusters just inside the leaf sheath, or on young leaves surrounding the head. When found attached to calyx hairs the eggs occur either singly or in very small clusters. When found between the leaf sheath and the head the

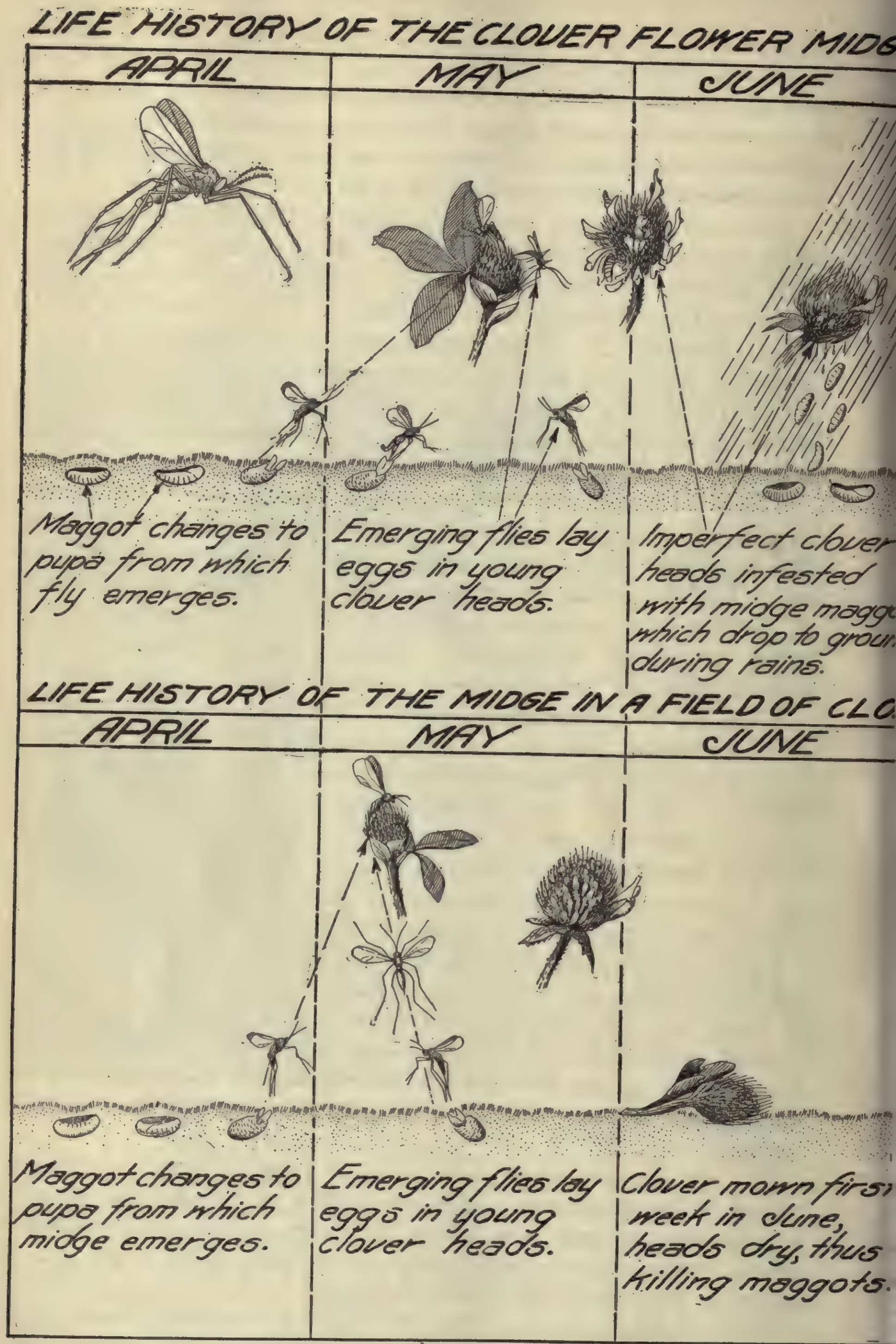
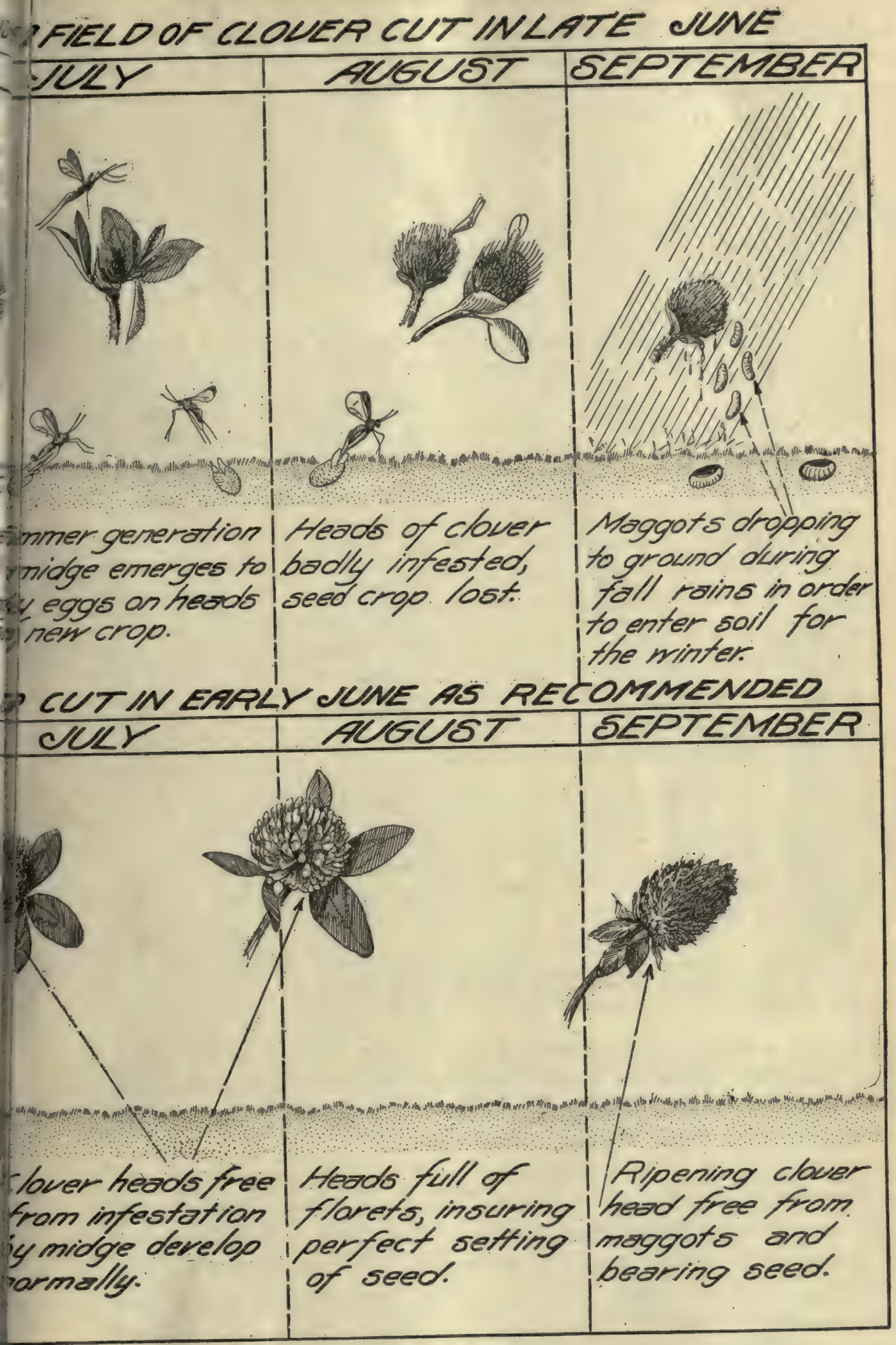

LIFE HISTORY OF THE CLOVER FLOWER MIDG
APRIL
MAY
JUNE
Maggot changes to pupa from which fly emerges.
Emerging flies lay eggs in young clover heads.
Imperfect clover heads infested with midge maggo which drop to grour during rains.
LIFE HISTORY OF THE MIDGE IN A FIELD OF CLO
APRIL
MAY
JUNE
Maggot changes to pupa from which midge emerges.
Emerging flies lay eggs in young clover heads.
Clover mown firs week in June, heads dry, thus killing maggots.

FIG. 3.—Diagram showing season



story of the clover-flower midge.

clusters are usually larger and contain from 10 to 20 eggs. In the laboratory a single midge has been observed to lay as many as 86 eggs, but as the majority of females when they emerge from cocoons are found to contain over 100 eggs, it is probable that the latter number is a better indication of what the average female actually lays under field conditions. It is not unusual to find considerably more than 100 eggs in and about a single head, or more eggs than there are florets. A midge generally spends only a few minutes on a head, placing a few eggs in one or two locations and then flying on to another.

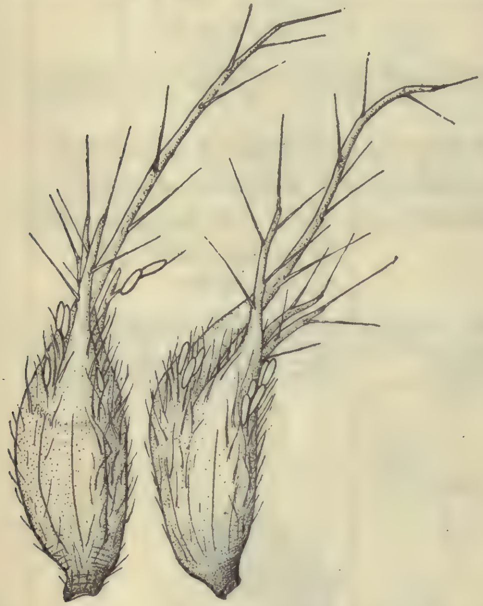


FIG. 4.—Eggs of the clover-flower midge fastened to hairs of calyx in immature red-clover flowers. Highly magnified.

The eggs hatch in from three to five days, the length of the egg period varying with the temperature. A larva, or maggot, upon hatching from the egg is of a watery, pale yellowish color, with an internal bright orange spot plainly visible to the naked eye. The young legless maggot wriggles to the top of the floret and forces its way inside through the unopened petals. Upon obtaining entrance, it works its way down to the young ovary; here it feeds by sucking the juices from this part of the flower, thereby destroying the ovules and thus preventing the formation of seed. Usually only one maggot is found in a single floret, but occasionally two or more are found. A floret infested with a midge larva shows the injury very plainly, as the petals rarely expand. Infested heads therefore are distinguished easily, their imperfect blossoming giving them an irregular or mangy appearance. (Fig. 2 and title-page illustration.)

The time required for a midge larva of the spring generation to complete its growth is approximately four weeks. Few of them complete their development before the last of May, and mature larvæ are not found in the clover heads in noticeable numbers before the end of the first week in June. If the season is exceptionally late it may be impossible to find full-grown maggots before the second or third week of the month. The maggots not only grow rapidly but undergo a pronounced change in color while feeding in the florets. They change gradually from a watery yellow to creamy white as they increase in size, and shortly before reaching maturity become a salmon pink, remaining this color until becoming full grown. Upon reaching maturity the maggots measure approximately one-tenth of an inch in length and entirely fill the florets, taking the place of the seed.

The mature larvæ do not drop at once to the earth to pupate but await sufficient rain thoroughly to moisten the clover heads and the surface of the ground. In Oregon and Washington it is not uncommon for two or three weeks to elapse between the date of maturity of a considerable percentage of the midge brood and the occurrence of a sufficient amount of rainfall to bring them out of the heads. After dropping out of the clover heads in June the maggots work their way a short distance into the ground, generally through small cracks in the soil, and lose no time in spinning cocoons similar to those in which the parent generation passed the winter. Unless it becomes exceptionally dry immediately following the spinning of cocoons, the maggots of the summer generation do not remain dormant in the cocoons but pupate at once. The pupa period at this season of the year is generally from two to three weeks, but a spell of dry weather will often lengthen it, and a prolonged drought such as occurred during the summers of 1914 and 1917 results in the death of many of the larvæ and pupæ.

The first adults of the summer generation may be expected to appear in the fields any time between July 1 and 15. If there is a fair amount of rainfall during July they emerge in constantly increasing numbers until about July 22. After this date there is a rather rapid decrease in numbers until about the middle of August, when very few are to be found. On the other hand, if there is no rainfall during July this generation will be relatively scarce, reach its height, and completely disappear by the middle of that month. The adults of this generation lay their eggs in the young heads of the seed crop, where they hatch and undergo the same development as described for the spring generation.

The maggots of the summer generation also require approximately four weeks to reach maturity. Most of them complete their growth in early August, but if the summer is dry they frequently remain in the heads until the clover is hulled, or, if the crop is left standing, until the fall rains occur. If sufficient rain falls during the late summer, however, they drop to the ground, pupate, and emerge as adults during late August, September, and, occasionally, well into October. The adults of this third generation lay their eggs in the late heads in the fields from which they emerge, and probably also in the young heads of the spring-sown clover, which frequently appear at this season of the year. The greater part of their progeny have ample time to complete their growth before killing frosts occur. In any case, sufficient progeny of either the second or third generation of midges survive the winter to emerge as adults and propagate during the following spring.

CONTROL MEASURES.

PASTURING.

The practice of pasturing red clover previous to starting a seed crop has proved to be as effective a means of midge control in Oregon and Washington as it was shown to be in Ontario, Canada, and in our eastern States. In favorable seasons clover often makes sufficient growth the first year to enable the farmer to begin pasturing in the early fall. Fall pasturing is valuable in that it keeps down the volunteer heads in which the midge would otherwise secure a foothold in the field the first season. In any event, the clover always makes sufficient growth to permit pasturing the following spring. Pasturing the field during April and May exterminates the midge, either directly by the destruction of the clover heads containing the eggs and partially grown larvæ, or indirectly by preventing the heads from forming during the time the adults of the spring generation are laying their eggs. The live stock may be removed from the field the latter part of May or left until early June, depending upon the season. In case the pasturing has not been close enough to get all of the heads, a mower should be run over the field shortly after the stock is removed in order to cut what remains. This practice not only results in the destruction of the immature midge larvæ which may happen to be present in these heads but also keeps down the weeds that otherwise might be present in the seed crop.

EARLY CUTTING.

As the majority of farmers raising red clover desire to secure both hay and seed crops, the practice of early cutting of the hay crop has to be resorted to in midge-infested districts. This method of midge control has for its object the destruction of the first brood of midge maggots by the cutting off and drying up of their food supply. Early cutting can be practiced successfully by the clover-seed growers of Oregon and Washington, but on account of the seasonal variations and general climatic conditions existing in the Pacific Northwest it is more difficult to lay down a general rule, stating approximately upon what date to cut each year, than it is in the Eastern States, where conditions are more nearly uniform. To practice early cutting effectively the farmer must not only keep himself informed as to the development of the clover itself (fig. 5) but also as to the development of the midge larvæ within the heads. The changing of tint of the larvæ in the majority of the infested heads in the field from a creamy white to a salmon pink indicates that they are rapidly approaching maturity and that cutting should not be delayed long if the majority of the larvæ are to be killed by this means.

Life-history studies made throughout four seasons of varying climatic conditions indicate that few of the maggots of the spring generation ever reach maturity before the end of the first week in June. Therefore it can be safely stated that if the clover is cut by June 1 the cutting will destroy the maggots of the spring generation regardless of the season and will assure an uninfested seed crop, except for such slight infestation as comes from the few scattered individuals that possibly may invade the field from the roadsides or that may be blown over by the wind from a neighboring. field. (See fig. 6.)

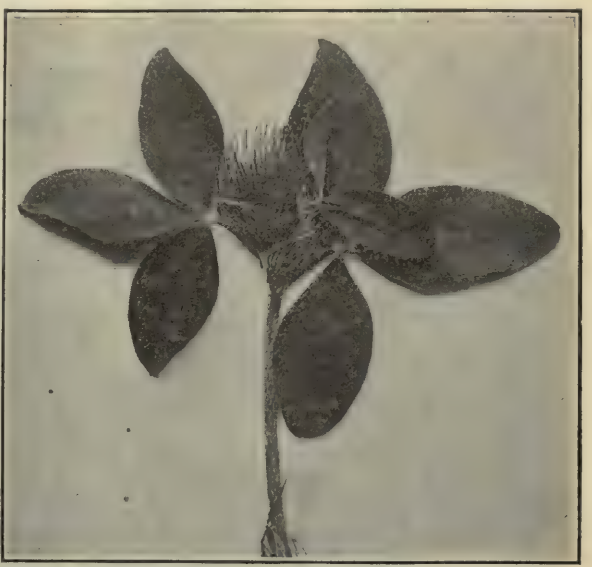


FIG. 5.—Young clover head showing stage when clover-flower midge lays its eggs.

Further investigations and experiments, however, have shown that in most seasons the clover can be cut at a slightly later date than June 1 with safety, thus enabling the farmer who is willing to assume the risk of unfavorable weather to obtain a greater amount of forage from his field than would be possible otherwise. The reason that this later cutting is usually effective lies entirely in the fact that midge larvæ, after they complete their development, do not leave the clover heads and drop to the ground to pupate until there has been sufficient rainfall to moisten the florets thoroughly. If, therefore, the hay crop is cut and removed from the field any time between the first week in June and the date of the first rainfall thereafter which exceeds approximately one-tenth inch, the result will be fully as effective as it would have been had the crop been cut while the maggots were still immature. As the date of this rainfall is uncertain, however, varying between the 7th and the 21st of the month, it is unwise to postpone cutting of the hay crop any later than necessary after June 1.

A good rule to follow is to cut the hay crop during the first week in June providing the weather is favorable. If it is rainy during that week, wait and cut the crop as soon as the sky clears and the weather becomes settled.

CLIPPING.

Some farmers, who desire neither to pasture nor to secure a hay crop, follow the practice of cutting their clover back between the 10th and the 25th of May, leaving the clippings on the ground as a mulch. In fields clipped May 15 or earlier, however, the seed crop is apt to be somewhat infested with the midge, owing to the fact that the clover makes sufficient growth to produce young heads in early June before the adult midges of the spring generation have entirely disappeared. The safest rule to follow is to clip not earlier than May 20. Clover cut about this date will not produce young heads until after the adults of the spring generation are gone, and these heads will be far enough advanced by the 1st of July to be immune from attack by any of the adults of the summer generation which begin to appear in the fields soon after that time.

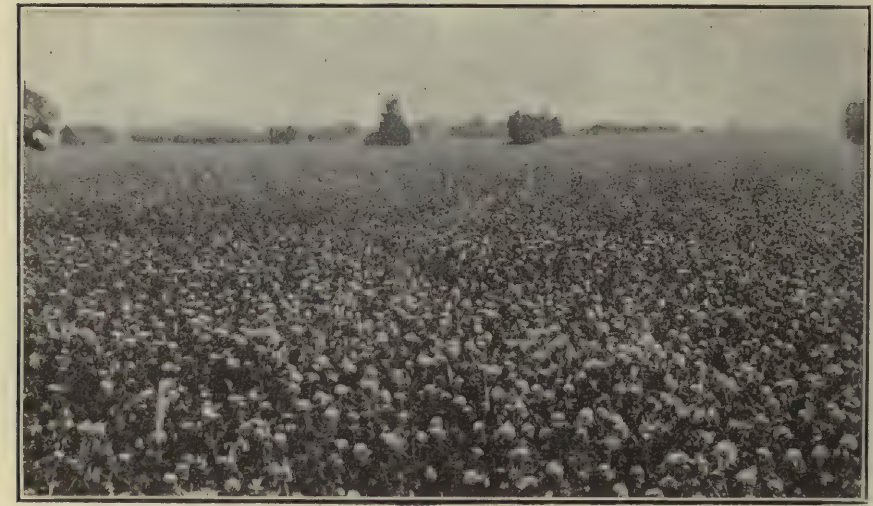


FIG. 6.—Field of clover from which the hay crop was cut June 1, the perfect blossoms showing the absence of the clover-flower midge.

SOILING.

A few farmers who combine clover-seed production with dairying find it desirable to cut their clover and feed it green during the spring and early summer. This practice, known as soiling, affords an effective means of controlling the midge, providing the same precaution is taken as in clipping; i. e., that the clover be held back sufficiently to prevent young heads of the seed crop from developing before the middle of June. In cases where the clover has been cut in late April or early May it may be necessary to cut it a second time about June 1 in order to accomplish the above result.

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HAYMAKING

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Agriculturist

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UNITED STATES DEPARTMENT OF AGRICULTURE

OFFICE OF THE SECRETARY

Contribution from the Office of Farm Management

W. J. SPILLMAN, Chief

Washington, D. C. April, 1918

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HAYMAKING is an operation that must be done in a certain space of time that is short at best and that is always liable to be made shorter by bad weather. For this reason there is perhaps no farm operation in which system and efficiency count for more than in haymaking; yet throughout the hay-growing area more or less haphazard methods of haymaking are still very common.

This bulletin is designed to point out ways in which the more successful hay growers of the country save time and labor in this important field work. It tells how the growing scarcity of farm labor may be met by rearranging crews and changing methods, and by the adoption of up-to-date implements, such as the hay loader, push rake, and stacker. In addition to outlines of methods for various sized crews and acreages the bulletin presents, briefly, a discussion of the theory of curing hay, a thorough understanding of which is a great help in planning an efficient method of haymaking.

HAYMAKING.

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NEED OF REDUCING HAYMAKING COSTS.

THE HAY CROP causes more worry, anxiety, and disappointment than any other crop. It is the most widely grown crop on farms devoted to general agriculture; the time for harvesting is comparatively short and haymaking can not be postponed without a consequent loss of quality and quantity. In many sections there are other crops that require attention about the time that the hay should be made, and often there is small grain to be cut, corn to be cultivated, and hay to be made, all at once. Labor is not only scarce but expensive. And there is the weather to be reckoned with, a factor that has a very important bearing upon quality and one over which the farmer has no control.

Hay has been quite steadily increasing in acreage for a number of years, until at the present time it occupies about one-sixth of the tilled area on farms in the United States, and has an annual value on the farm, unbaled, of over $1,000,000,000. There are no statistics on the actual cost of producing the total annual crop, but it has been roughly estimated that it costs $125,000,000 or more to harvest this enormous tonnage.

A reduction of even a small per cent in this cost would add millions to the profits of the hay growers of this country. Such a reduction can be brought about only by the use of modern haying machinery and of methods of making hay best suited to conditions.

It is the purpose of this bulletin to describe and discuss the different systems and methods of making hay in vogue in various parts of the country, in order to give the farmer who is interested a general idea of the haymaking practices followed by successful farmers in other sections.

CHOICE OF METHOD OF CURING.

FOR MARKET OR FOR HOME USE.

The first point to be considered in making plans for putting up hay is the quality desired. This is especially necessary when making timothy and timothy mixed hay. Quality, in this instance, refers to the differences in grade between properly cured cuttings of hay made at different stages of maturity.

Every farmer tries to make the best quality of hay possible, as it is more nutritious and more salable than hay poorly made, but many a farmer's idea of "choice" hay is radically different from that of those who feed hay in the city. Farmers often prefer timothy hay that is cut after the "full-bloom" stage is passed, while "choice" hay on the city market is hay that is cut during "first bloom." There is a difference of more than a week between dates of cutting these two kinds of hay.

"Choice" hay is not handled as is late-cut hay. It contains more moisture when cut, and to cure it requires a longer time and often more labor than to cure hay cut later. If the hay is to be sold on the city market the grower will have to exercise special care in curing, and possibly use haying machinery not needed in curing hay for use on the farm.

ACREAGE TO BE HARVESTED.

The acreage grown has an important bearing upon the method of making hay. When the acreage is small, as it often is in the East, it would not be practical to make a heavy investment in machinery that would only be used a very few days each year, while with a large acreage it is advisable to use machinery as much as possible in order to do away with expensive and arduous hand labor and to increase the tons handled per hour per man.

CROP GROWN.

Grass hays are, as a rule, easier to cure than legume hays, since grasses have hollow stems, a finer texture, and fewer leaves. Care must be exercised to rake legume hay before the leaves become so dry and brittle that they will break off and cause a heavy loss of the most nutritious part of the plant. The leaf loss caused by raking grass hay is small compared with the loss sustained in handling legume hay.

The first and last cuttings of alfalfa in nonirrigated sections are often very hard to cure. In some sections rains are frequent during the first cutting, and cool weather during the last cutting, which prolongs the curing, making it necessary to cock the hay and cure it in the cock.

Grass hay is usually made in midsummer, when the temperature lends itself to rapid curing in the swath and windrow, and, as a rule, cocking is not necessary.

LABOR SUPPLY.

Availability of labor has an important bearing on the method that should be chosen for making hay. Very often, when labor is hard to get, a small crew can be so handled as to do the work customarily done by a larger crew. In some cases, when labor is scarce, the method used when there is plenty of help will have to be discarded and an entirely new method adopted, which will require different machinery from that formerly used. For example, in cases where the old method of pitching the hay onto the wagon by hand and hauling it to the stack has been followed, the work may be done with fewer hands if push rakes and the stacker are used.

YIELD PER ACRE.

The yield per acre influences in two ways the method to be used. First, if the yield is heavy and if the hay is a legume or a legume mixture, it will necessitate the use of the tedder and perhaps cocking the hay. Second, many farmers plan to cut their hay at the stage of maturity when the greatest weight will be obtained, and this raises the question of the proper time to cut hay. In determining this, the question of time to cut to obtain the greatest feeding value should be considered, as well as that of securing the greatest number of tons.

WHEN TO CUT.

Timothy cut just as it is coming into full bloom is much harder to cure than when cut with the seed in the dough stage or nearly ripe. When cut early it contains a larger percentage of moisture than when cut later, and consequently must remain longer in the swath and windrow and run greater risk of being injured by rain. For this reason, many hay growers prefer to wait until the hay can be cut and hauled in the same day. Also if cut after the blooming period it will yield more to the acre by weight than when cut in full bloom, but the feeding value decreases quite rapidly after the plant is in full bloom.

Waters[1] found that the yield of a timothy crop coming into bloom was 3,411 pounds of dry matter to the acre; the yield at full bloom was 5,433 pounds; the yield when seed was formed was 5,793 pounds; the yield when seed was in the dough, 5,750 pounds; and when the seed was ripe, the yield was 5,193 pounds per acre. From this and other experiments it will be seen that the dry matter increases up to the time the seed is in the dough, after which it decreases.

The protein content when coming into bloom was 260.9 pounds per acre; was greatest (292.6 pounds) when the plant was in full bloom, and decreased from the time of full bloom until the seed was ripe, when it amounted to 218.6 pounds per acre.

From this it will be seen that the greatest feeding value is secured if the hay is cut at about the time the plant is in full bloom. The yield per acre is somewhat greater if the hay is cut after full bloom, but the gain in feeding value and grade, as indicated by color, when cut at full bloom, more than offsets the value of the gain in weight per acre when cut later.

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[1] Proc. Soc. Prom. Agr. Sci. 31, 1910; pp. 71–98.

HOW HAY CURES.

When hay "cures" there are perhaps a number of processes or changes that take place within the plant, but there are two that are very important, i. e., the throwing off of a comparatively large amount of water and a chemical change commonly known as heating or fermenting.

The quality of hay depends upon the ability of the farmer properly to control the manner in which these changes take place. Of the two changes mentioned, the first is the more important, for if the hay is properly dried the second, or heating process, will take care of itself.

There is no time limit in the curing of hay, for it is simply a matter of reducing the moisture in the plant from about 75 per cent down to about 15 or 20 per cent in the quickest time possible.

In order to cure hay properly, so that it will retain the natural green color and save the greater per cent of the leaves, it is necessary to get rid of the moisture as quickly and evenly as possible from all parts of the plant at the same time.

THE FUNCTION OF THE LEAVES IN CURING.

In growing plants there is a constant stream of water entering the roots, carrying plant food through the plant to the leaves, where the water is thrown off by transpiration. When the plant is cut off, as in the case of hay plants, the leaves, if kept alive, will continue to transpire or "pump" the water from the plant until a large per cent of it has evaporated.

Keeping the leaves alive and giving all of the plants in the swath as nearly an equal chance as possible to get rid of moisture, is the whole art of curing hay. It has been said that "Sun kills the hay plant, but wind lets it breathe itself to death." When the yield is heavy and the hay is exposed to the direct rays of the sun, the leaves on top of the swath soon lose their moisture, become brittle and dry, and are of no further use in helping to remove the water from the plant, and curing must continue by means of direct evaporation, which is a slow process as compared to curing by transpiration through the leaves.

FERMENTING OR HEATING OF HAY.

In addition to the loss of moisture in curing, there is the other process, commonly known as fermenting, heating, or sweating, which takes place in the cock, barn, or stack. This process in stacked or barn hay is usually finished in from three to six weeks.

Exactly what takes place during this process is not known. The change is a chemical one, and is due to the presence of moisture in the hay. It is thought that the hay develops aroma and becomes more palatable during this process. It is known that fermentation is accompanied by a loss of moisture.

Hay that is put up not sufficiently cured, or that is wet with rain, develops considerable heat from fermentation, and spontaneous combustion may occur rarely in grass hay, but more often in clover or alfalfa hay, especially first cuttings.[1]

Spontaneous combustion is indicated by the hay becoming darker in color until it is finally black, by a sooty odor, and by smoke irritating the eyes. The ash of the burnt hay has a characteristic grayish-white appearance and feels like sand. The burnt hay is surrounded by a layer of charred but not burnt material, which is a poor conductor of heat. A number of cases of spontaneous combustion of alfalfa hay are described in detail in Bulletin 109 of the Kansas State Agricultural Experiment Station, issued in 1902.

EFFECT OF RAIN.

It is a matter of common knowledge that hay exposed to successive rains is injured in quality and loses in aroma and palatability. A light rain or a heavy dew does but little injury to freshly cut hay in the swath. Indeed, many farmers whose acreage is not large disregard dewfall and prefer to mow hay in the afternoon, thus giving the hay a chance to wilt overnight. Rain causes partly cured hay to become bleached and mouldy, and continued warm rains dissolve and carry away a considerable portion of the nutrients.

Hay should never be raked, cocked, or put into the stack or barn when there is any dew or rain on it. Such hay is very liable to mould or heat, and even spontaneous combustion may occur.

If a rain comes on when the hay is partly cured in the swath, it is bad practice to rake it into windrows, for it will be damaged no more in the swath than in the windrow. Hay that gets wet in the windrow will have to be spread out later to dry. The same holds true about cocking. In case of rain, nothing is gained by hurriedly cocking or bunching hay that is almost cured, unless large hay caps are put on the cock. When such hay is rushed into the cock it will not turn water and will be wet all the way through, and if not scattered out after the rain is over will soon begin to heat and will spoil.

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[1] According to F. H. Hoffman (Zeitschr. Spiritusind., 1897, Nos. 3–50, abs. in Entbl. Agr. Chem. 27 (1898) No. 6, pp. 395–6), when spontaneous combustion occurs in clover, heat is generated in the hay, oxygen being taken up from the air and the organic matter transformed into carbon dioxid and water. The water moistens the hay, and the moistened material ferments, owing to the presence of bacteria. The fermentation also produces carbon dioxid and water, as well as small amounts of hydrocarbons, hydrogen, organic acids, enzymes, etc. Heat is also produced from the fermentation. The fermentation is more rapid if the clover is moistened at the beginning. However, the water produced by the oxidation of the material is sufficient to start it. The fermentation of the hay causes a temperature of 133° F. At this temperature a more violent oxidation takes place and the temperature rises to about 194° F. Other processes then take place which char the material and cause a slow rise in temperature to 266° F. When this temperature is reached, the hay rapidly heats and the charring proceeds rapidly. All these processes destroy at least half of the material. Theoretically the temperature may reach 374° F.

According to the tests made, clover hay will become ignited at 302° F. to 392° F. Therefore, the temperature may rise sufficiently high to cause spontaneous combustion. Oxygen from the air is essential to combustion.

HAYING OPERATIONS.

MOWING.

Sizes of mowers used.—The most common size of mower in use to-day is the 5-foot cut. A fair day's work with this machine is about nine acres, while with the 7- or the 8-foot machines, which are gradually growing in favor among farmers who grow considerable hay, 13 or 15 acres per day, respectively, is a fair day's work. In other words, two horses and one man with an 8-foot mower will do two-thirds more work per day than when a 5-foot mower is used. With the 8-foot cut the cost per acre for man and horse labor will be 30 cents, while with the 5-foot cut it will be 50 cents. The saving in labor charges with the larger machine will, in almost all cases, considerably more than offset the slight additional overhead expense of interest and depreciation on the larger initial investment involved.

Unless there is a valid objection to the use of the 7 or 8 foot mower, such as a very limited acreage, exceptionally heavy growth of fine grasses and weeds, or rough and uneven ground, the larger machines should be employed. Too many farmers have continued the use of the small machines because of fancied objections to the larger sizes. In many instances where one large mower will cut sufficient hay per day to keep a crew busy the use of a smaller size makes it necessary to use a second mower a few hours per day. At harvest time labor is usually extremely scarce and at a premium, and any saving which can be effected is especially valuable for that reason. The larger sizes of mowers reduce the size of the crew required and save time at critical periods, the value of which is often considerably greater than the mere wages involved.

Mowing practices.—There is considerable difference of opinion among hay growers as to the best time of day to mow hay. Some never cut hay when the grass is wet, others start mowing at any time, and some mow in the afternoon only.

When considerable hay is grown it is necessary to keep the mowers going most of the day. Some growers of alfalfa in the South and East mow hay even when a light rain is falling, because unfavorable weather makes it impossible to get the crop up in time if the mowing is all done in good weather.

When the acreage grown is small, it is customary to wait until the dew is off or to cut only in the afternoon. While this practice is desirable in some cases, in others it is merely wasting valuable time and it should be followed with careful judgment. In other words, the hay grower should inform himself by experiments or by the experience of his neighbors as to the earliest possible time in the morning after a heavy dew at which it is safe to start mowing under different conditions, considering the amount of moisture contained in the upper surface of the soil, whether the yield is light or heavy, the weather, and whether or not a tedder is to be used. All possible loss of valuable time, such as is entailed by having hired help idle or employed at work which is less profitable and necessary than making hay, should be avoided. (See fig. 1.)

It is important to know how much hay to have down at one time. It is not good practice to have two or three times as much hay cut down as can be hauled or taken in in one day. Loss of quality can be avoided somewhat by having the mowers only one day ahead of the crew hauling; then if a rain comes up a minimum amount of hay will be damaged. (See fig. 1.)

TEDDING.

The best way to cure out freshly cut hay is to stir up the swath with a tedder before the top leaves dry out. When the leaves lose their moisture and become dry before the moisture from the stem is removed, the process of curing is very much retarded. The tedder is especially valuable in curing alfalfa and clover hay, or heavy yields of any kind. No set rule can be given for using the tedder, but it should follow the mower from 2 to 6 or more hours later, depending upon yield, kind of hay, velocity of the wind, temperature, clouds, etc. The function of the tedder is to kick up the hay and allow it to cure out evenly (see fig. 2). The tedder does more damage than good by breaking off the leaves, if used after the leaves have become dry. It is used on hay in the swath, seldom on hay in the windrow.

To induce rapid curing, it is the custom of some hay growers to ted the hay twice the same day.

RAKING.

The practice of raking hay into windrows with either a sulky (dump) or side-delivery rake is almost universal. The exceptions are where the hay is loaded on the wagon directly from the swath by means of a hay loader, or is gathered from the swath with a sweep rake. These practices are rare, being followed usually only when the yield is heavy.

It is safe to say that most hay is cured almost entirely in the swath; indeed it is a common practice to commence hauling or stacking hay immediately after it is raked. Under certain conditions this practice is allowable. When the yield is light, or when a heavy yield is stirred several times with the tedder, and especially if the day is cloudy and there is a good breeze stirring, hay can be entirely cured in the swath and a good quality made.

During hot, dry, sunshiny weather in the middle of the summer, however, this practice of curing in the swath will not produce the best grade of hay. Under such conditions hay, especially clover and alfalfa, should be raked into the windrow just after it is all well wilted and before the leaves become dry enough to break off when raked.

After being raked, the hay may be left in the windrow until it is ready to be moved, or it may be put into cocks and left until thoroughly cured. Hay is ready to be removed from the windrow when a wisp can be broken to pieces if given two or three twists in the hands.

The side-delivery rake has one advantage over the sulky rake. When the curing is done in the swath the crew can start taking the hay from the windrow as soon as the side-delivery rake has made one double windrow across the field, whereas when the sulky rake is used they will have to wait until the rake has gone several times across the field.

Some hay growers object to the use of the side-delivery rake for clover and alfalfa, claiming that it breaks off so many leaves as to cause a serious loss of the most nutritious part of the plant. This

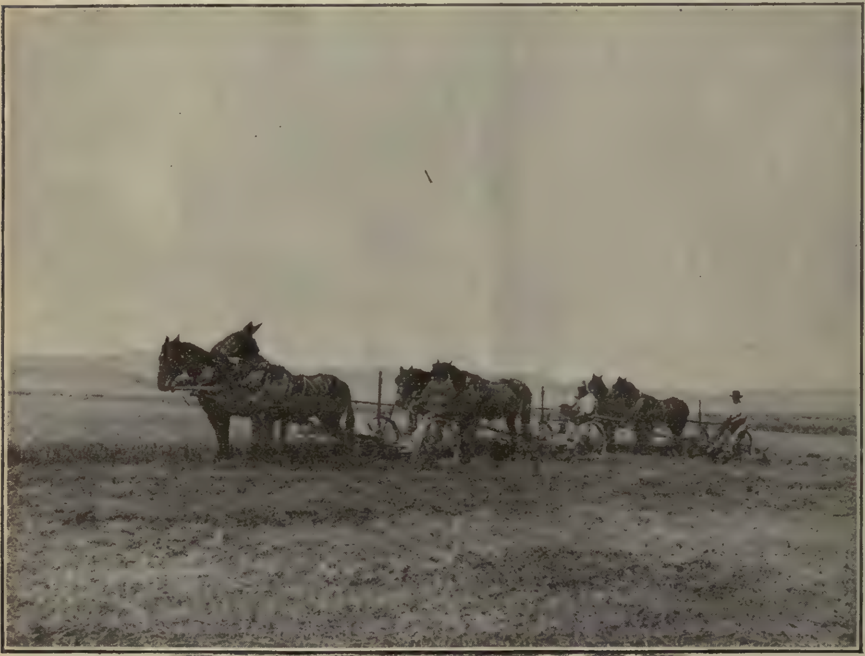

FIG. 1.—It is not a good practice to keep the mowers as close together as this. The fastest team should be in front in order to do the maximum amount of work.

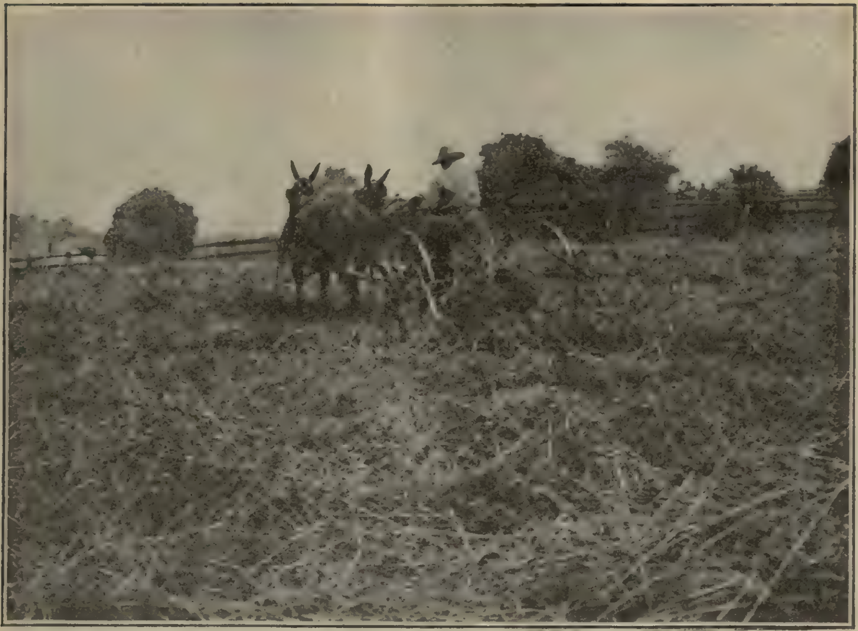

FIG. 2.—The hay tedder should be used soon after the hay is cut in order that the hay may be cured quickly and evenly.

is undoubtedly true if the hay is raked when sufficiently cured to be put into the stack or barn, but this objection does not hold good if the raking is done when the leaves are merely well wilted. (See fig. 3.)

CURING IN THE COCK.

One of the best methods of curing hay is to cure in the cock. This method is not generally practiced except in regions where unfavorable weather is the rule rather than the exception, or when the best quality of legume hay is desired. Throughout the Middle West, where hay loaders are used, hay is not cocked because of the extra labor required and the inability to handle cocked hay with the hay loader.

It has been shown that it is necessary to get rid of the water in the plant evenly. On a sunshiny day hay must be raked after it has been in the swath a certain length of time, or the leaves will become dried out and lose color. When it is raked into the windrow a smaller proportion of the hay is exposed to the action of the sun's rays. After remaining in the windrow, where further curing is done, the time is reached when it becomes necessary to remove the hay in order to retain a good color and aroma.

When this stage is reached the next thing to do is to put the hay into the cock, where a still smaller proportion of the hay will be exposed to the sun. The curing process is not stopped when hay is cocked, but goes on less rapidly than when in the windrow and much more slowly than when in the swath. The hay in the cock continues to lose its moisture slowly until it is cured out sufficiently to be baled or put into the stack or barn. The time required for curing will depend upon the moisture content when cocked, the amount of hay put into the cock, and also upon weather conditions.

Under ordinary conditions hay will cure in the cock in from three days to a week. Hay cocked too "green" will cause heating. The larger the cock the more danger there is of heating when undercured hay is cocked. Hay is put into cocks containing from 75 to 700 pounds of cured hay. About 100 pounds is the size most commonly used in many sections.

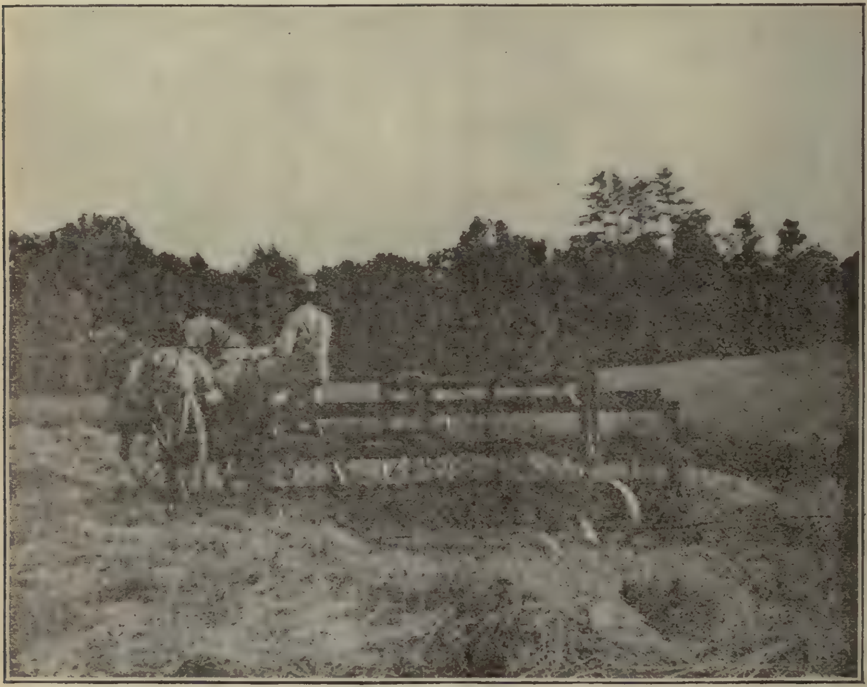

FIG. 3.—The side-delivery rake should be used before the leaves become dry enough to shatter when raked.

Cloudy and rainy weather not only retards curing but may cause heating if the rain enters the cock. When cocked hay shows danger of becoming too hot it will be necessary to open the cock and scatter the hay out until it has lost enough moisture to be recocked.

Hay can be put in small cocks greener than in large ones. Some farmers take hay from the windrow and make very small bunches, each containing about three forkfuls of hay, before the hay is in condition to be put into a regular sized cock. The second day several of the small bunches are put into a large cock, where it remains until thoroughly cured.

Another reason for curing hay in the cock is that there is a very considerable saving of leaves when making legume hay. The economy of curing in the cock must be governed by other factors to be mentioned later.

HOW TO COCK HAY.

There are two ways to make a hay cock. One is to roll up the hay in the windrow into a rather loose cock or bunch, or to round up (cock) bunches of hay that have been bunched with the sulky or push rake, after the hay is almost cured. The bulk of the hay in this kind of a cock is not handled, being left rolled up and tangled from the action of the rake. The edges are pulled out with a pitchfork and put on top of the cock. Such cocks are subject to considerable settling, and flatten out and do not shed rain. This practice is suitable for curing in good weather, as a man can handle more than twice as much hay as when cocking the other way. It is a waste of time, however, to cock hay in this manner if it is to be exposed to rain, unless hay caps are used; for the rain will wet and spoil the hay.

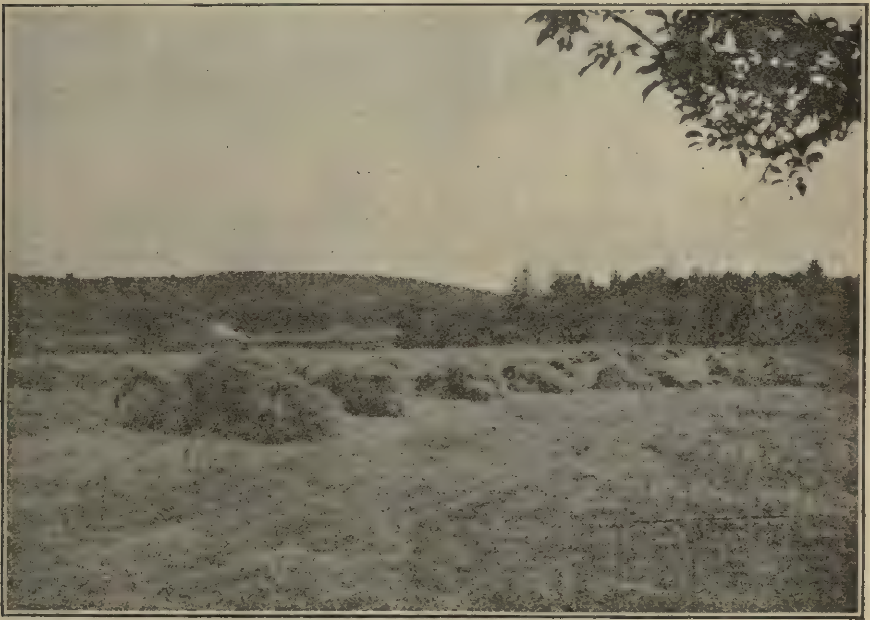

FIG. 4.—Curing hay in the bunch. Hay will cure out better when loosely bunched than when in the swath or windrow, but a heavy rain will wet it clear through.

The best and correct way to build a cock, when working with fairly green hay, is to take the hay, a forkful at a time, and spread it out flat. Care should be taken to build a good, symmetrical cock, in the same manner as a stack is built. The top should come to a sharp peak, and, when the last forkful is on the sides, should be raked downwards so that the stems will cause rain to run off and away from the center of the cock. Cocks built in this manner will shed

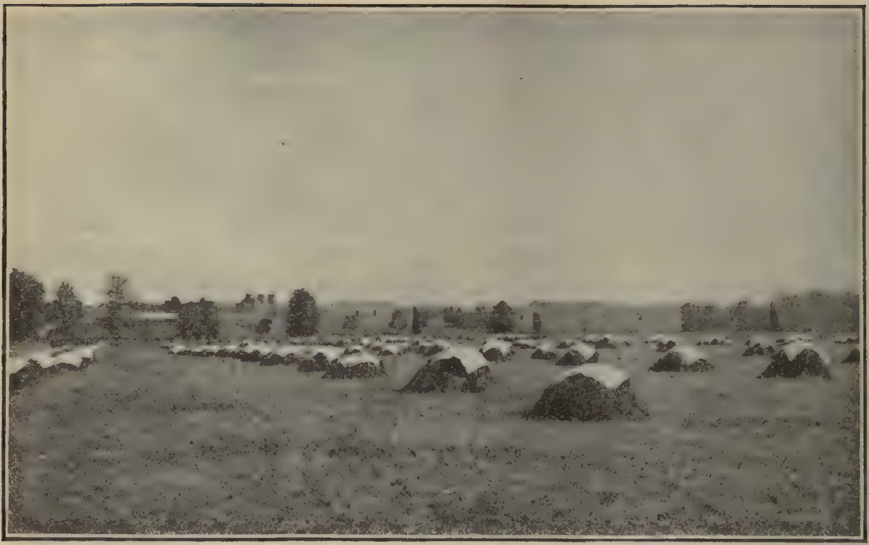

FIG. 5.—Curing hay in the cock under caps. When weather conditions make it necessary to cure hay in the cock it is advisable to use hay caps.

considerably more rain than when most of the hay is rolled up or bunched. Well cocked hay covered with caps can, if necessary, remain in the field over a week.

SYSTEMS OF MAKING HAY.

There are four distinct systems of making hay, each of which is divided in actual practice, into several methods. The distinguishing features of the four systems are as follows:

1.—Loading is done by hand.
2.—Loading is done with hay loader.
3.—Push rakes and stacker are used.
4.—Hay is baled in the field, using push rakes and horse or power press.

SYSTEM No. 1: LOADING DONE BY HAND.

This is the oldest system and the one most generally used in the older hay-growing sections of the East. Its retention in these sections is due largely to the fact that it requires a minimum amount of equipment, which makes it particularly suited to farms where only a limited acreage of hay is grown.

The equipment required includes only mowing machine, rake, pitchfork, wagon and rack, and, in most cases, unloading apparatus such as hay forks or slings.

Nearly every one is familiar with this system, which consists merely of pitching the hay on the wagon with hand forks and hauling to stack or barn, where it is either pitched off by hand or unloaded with horse forks or slings (see figs. 6, 7, and 8).

While it can be used under almost any conditions, this system involves a large amount of irksome hand labor, and for this reason, as well as the greater expense for labor, it should be replaced by some other system whenever practicable.

SYSTEM No. 2: LOADING DONE WITH HAY LOADER.

The hay loader is used most largely in the timothy and clover hay area. It is used to a certain extent in New York and Pennsylvania, and to a greater extent in Ohio, Indiana, and Iowa.

In some localities there exists a prejudice against the loader. The first loaders put on the market were not mechanically perfect, and therefore did not always give satisfaction, and the delay caused by break-downs influenced many to abandon their use. Moreover the loader often has been used on uneven or stony ground, with a resultant frequent breaking of vital parts. This use of the loader, under conditions not recommended by the manufacturers, also has tended to limit its popularity.

Another, and perhaps the most important, reason for the loader not being used more generally is that to use it economically the men on the wagon must work very hard while the load is being put on. A study of the use of the loader in several States has revealed the fact that the hired men as a rule do not like to work on the loader,

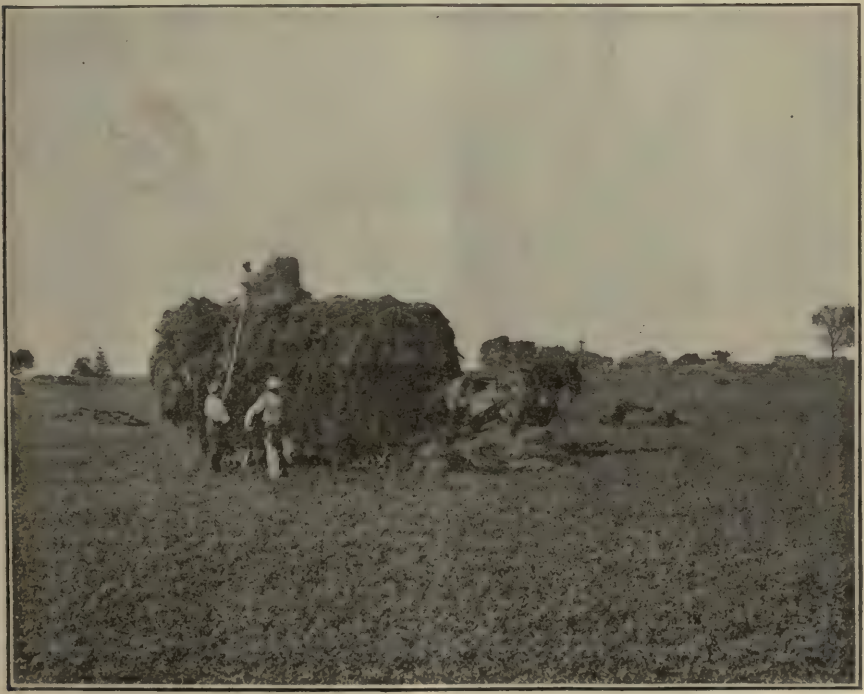

FIG. 6.—Loading wagon by hand. Loading hay onto a wagon with forks is not only hard work, but it is a very expensive operation. Less hay is handled per man than by any other method. Economical for small acreage only.

and for this reason push rakes and stackers have supplanted it on some farms in the Middle West.

On one farm it was noticed that when the owner was absent five loads were hauled in one afternoon, but when the owner was present and working on the wagon, seven loads were taken from the field in the same length of time.

At present there are two types of loaders. One picks up the hay with a revolving drum studded with spurs of spring wire about 6 inches long. The other type takes up the hay by means of a fork-like arrangement fastened to long wooden or steel arms. The bed of the carrier is now made solid, so that there is little likelihood of losing leaves from alfalfa, clover, and other legume hays.

FIG. 7.—Unloading hay at the barn with horsepower. This method of unloading is much more rapid than unloading by hand and man labor is almost eliminated.

The hay loader, under ordinary conditions, will increase the capacity of a crew about 30 per cent over that of the same crew pitching the load on by hand forks.

The loader is a valuable implement, and its saving in labor cost will be considerable, especially on farms where labor is scarce and expensive.

SYSTEM No. 3: PUSH RAKES AND STACKERS ARE USED.

Push rakes and stackers came into general use a number of years ago in the region from about the ninetieth meridian to the irrigated sections of the West.

A large percentage of the hay in this part of the country is stacked; and the comparatively large acreages grown, plentifulness of horses, scarcity of farm labor, and desire to make hay with the least amount of hand labor were incentives to the use of these two machines.

Push rakes, also known as "bull rakes," "go devils," "slip-arounds," consist of wheelless, two-, three-, and four-wheel types. They are capable of handling from 600 pounds to a ton of hay, depending upon the type, the skill of the driver, and the team.

There are several kinds of stackers, the overshot and swing-around being the most common. Homemade stackers are of various kinds, such as "gin poles," derrick stackers of different kinds, and inclines for handling hay from the large 1-ton push rakes.

The push rake and stacker make an admirable combination, since nearly all of the work of getting the hay from the field to the stack is done by horsepower. The push rake takes the hay from the windrow or bunch to the stack, where it is dropped on the stacker and elevated onto the stack by horses. The only hand labor necessary is that of placing the hay after it is dropped on the stack.

Fig. 8.—Pitching hay from wagon to stack by hand. This is a slow, irksome, and expensive method of getting the hay onto the stack. Economical for small acreage only.

These implements can be used with small crews, consisting of 2 men, up to crews of 12 or more men.

SYSTEM No. 4: HAY IS BALED IN THE FIELD USING PUSH RAKES AND HORSE OR POWER PRESS.

The practice of baling in the field from the windrow began in the semiarid Middle West, where there is but little danger of rain interfering. It has long been believed that hay is not in condition to be baled until it has gone through the "sweat" in the barn or stack. This process is usually finished from three to six weeks from the time the hay is made.

In the West, growers of prairie and alfalfa hay for the market realized that if it were possible to bale hay from the windrow a considerable saving of time and labor could be made. This saving would consist of a large part of the cost of putting the hay into the stack. They also began to doubt the necessity of allowing the hay to go through the "sweat" before it could be safely baled. Repeated trials and careful study have shown that a good quality of hay can be made when baled from the windrow under certain conditions. At the present time hay is being baled from the cock in parts of the South.

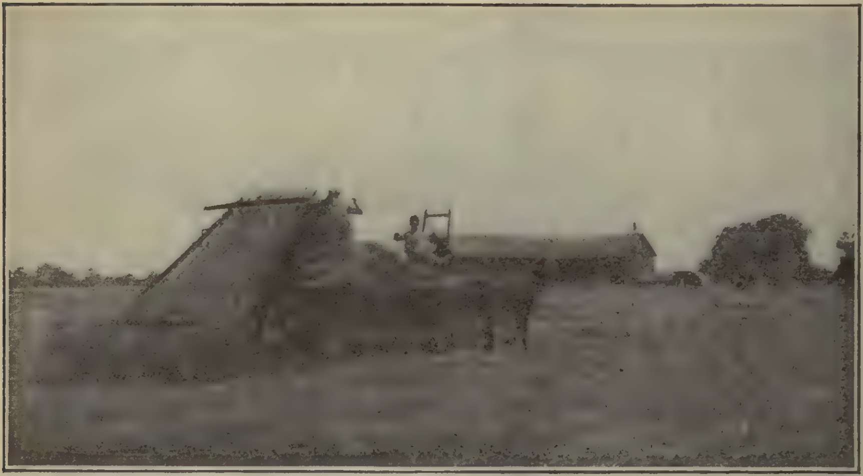

FIG. 9.—Hay loader in operation. The loader saves time and puts the hay on the wagon more cheaply than it can be pitched on by hand. It is necessary for the men building the load to work hard if the loader is used economically.

CONDITIONS SHOULD BE RIGHT.

Hay baled from the windrow often spoils so badly that it becomes unfit for feeding. This trouble is sometimes experienced by beginners and more especially when alfalfa or other legume hay is baled. There are three causes for this. First, the hay will not keep unless it is well cured in the field, it being necessary to cure it out more thoroughly than when it is to be put into the stack. Second, hay that is baled when partly wet with dew or rain is very liable to spoil. Third, hay is liable to spoil when the bales are improperly stored by being packed away close together. In many cases if the bales are placed on edge with an air space of an inch or two between, and the next layer placed crosswise with spaces there will be much less danger of heating and spoiling.

SIZE AND MANAGEMENT OF CREWS.

On many farms haymaking is carried on in a more or less haphazard manner, resulting in a loss of time, as now and then a part of the crew is idle. With small crews there is usually less loss of time than with larger crews, where some are mowing and raking, loading and hauling, and others working at the barn all of the time. A discussion of crew management will explain some of these points.

WHEN LOADING IS DONE BY HAND OR WITH LOADER.

SMALL CREWS.

The smallest economical crew for bringing hay from the field and putting it into the barn is the three-man and two-horse crew. In the East, the common practice is to load the wagon with hand forks and unload with the horse fork or sling. This arrangement allows two men to pitch on the load and one man to build the load on the wagon and drive the team. When the load is on, all three men go to the barn to unload. At the barn one man works in the mow, one sticks the hay fork on the wagon, and the third man drives the team on the rope. No time is lost, except that lost by the two pitchers in traveling between the barn and the field. In the East the average distance between these points is a quarter of a mile or less.

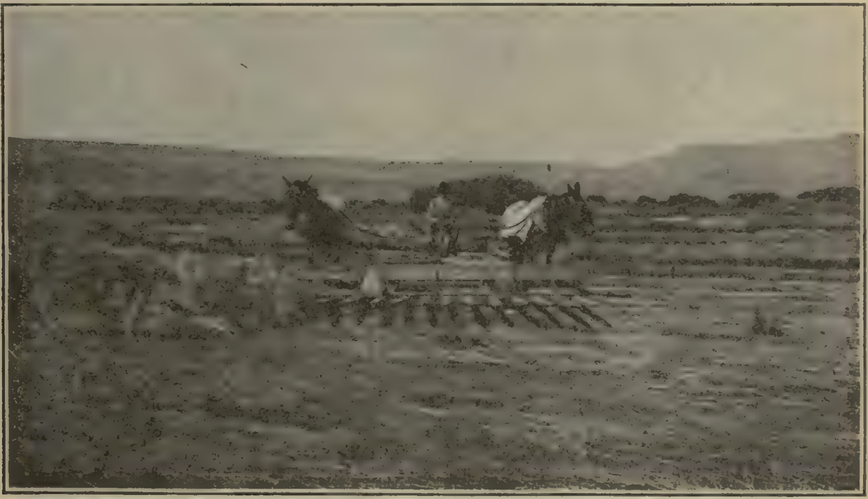

Fig. 10.—A four-wheeled push rake. This type of push rake is in general use in some sections of the West.

On most average-sized farms in the East the general custom is to haul hay in the afternoon only. In the forenoon, one man mows enough hay in about four hours, starting after the dew is almost gone, for half a day's hauling. Three to five acres, yielding 1.5 tons to the acre, is about all the ordinary three-man crew can handle.

The second man rakes every morning, at the beginning of the haying season, the hay that was mowed the day before. In the forenoon the third man does not work at haying at all, but is free to do other farm work, such as plowing corn, etc.

Let us see what the effect will be on the size of the crew if the hay is not cut until well past "full bloom," the stage of maturity at which hay (timothy, for example) must be cut if choice or "tea green" hay is to be secured.

Hay cut when past full bloom cures quite rapidly if the weather is favorable, and hay mowed in the forenoon can be put into the barn in the afternoon. This arrangement requires an extra man and two extra horses to rake the hay. To facilitate matters, the side-delivery rake should be used, so that loading can be started as soon as the rake has made one round. The fourth man will usually finish raking by 3 or 4 o'clock in the afternoon, and can help load during the remainder of the day. However, three men pitching onto one wagon is not ordinarily a very economical arrangement.

Now let us suppose that it is decided to do the mowing in the afternoon as well as the raking, and see how this arrangement affects the

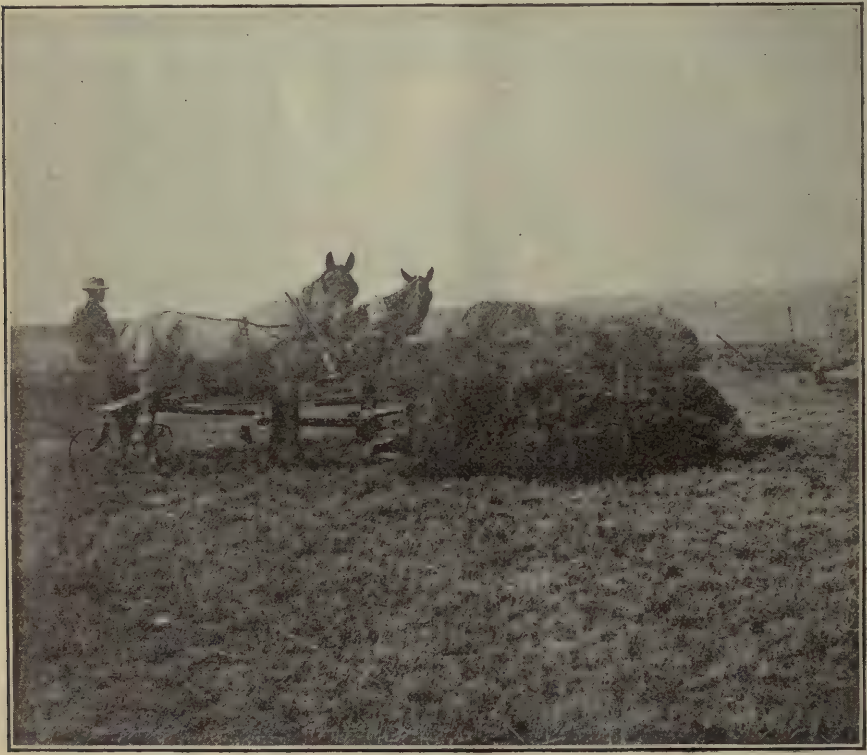

Fig. 11.—A push rake can haul from 600 to over 1,000 pounds per load, depending upon the type of rake. Hand labor is almost eliminated. Boys can operate the rake, provided the team is used to the work.

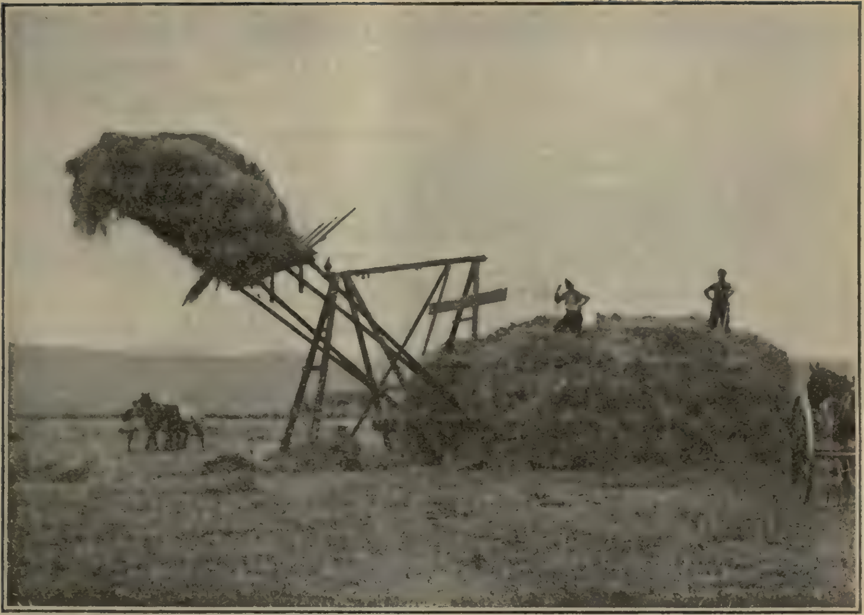

FIG. 12.—The stacker is a modern implement using horses for the hard work of getting the hay onto the stack.

size of the crew. Such a method requires another additional man and team, making a crew of five men working in the hay field in the afternoon only. There will be one man mowing, one raking the hay mowed the day before, and three men bringing hay from the field and putting it into the barn. Two more horses will also be required with this method, making a total of six, yet this larger crew will handle no more hay per day than the three-man crew above described.

The amount of hay that can be handled per year under these conditions will be from 40 to 60 acres, depending upon the yield. If the hay loader is used, more hay can be handled per day. The two pitchers work on the wagon building the load, and the third man drives the team.

MEDIUM-SIZED CREWS.

The difference in arrangement of work between small and medium-sized crews is that in the case of the larger crews a part of the men remain at the barn all of the time to unload and put away the hay. The smallest economical barn crew consists of three men, or two men and a boy. One man works in the mow, the other handles the fork or slings on the wagon, and the third man or boy drives the team on the hay rope. One method in common use is to have a barn crew of three, two men pitching in the field and one man to haul.

When the load is on, the pitchers remain idle in the field while the load is being hauled to the barn and the wagon returned. When the load reaches the barn, the team should be hitched to an empty wagon and return to the field at once. The difficulty with this method is that the pitchers lose time in the field; and since the barn crew can unload much faster than hay can be loaded and hauled to the barn, they too are idle a good part of the time.

Where the haul is short, as it usually is in the East, this method can be made more efficient by using two more pitchers in the field and one more man and team to haul and load. Three wagons will be required, as the load is left standing at the barn and the team returns with an empty wagon. With this arrangement the barn crew, pitchers and haulers, will all be busy all of the time. It may be necessary, in some cases, to put a second man at work in the barn to help mow away the hay.

LARGE CREWS.

Large crews are not often found where hay is loaded by hand, unless it be in sections where unfavorable weather is so common that it becomes necessary to cure the hay in the cock. This necessitates loading by hand or hauling with push rakes. It is not necessary to describe in detail the arrangement of large crews, for they are usually divided into units which work at different barns, as has just been described.

WHEN STACKING HAY WITH PUSH RAKES AND STACKERS.

SMALL CREWS.

The smallest crew that can be used to put hay into the stack when using the push rake and stacker is a two-man crew, but usually a three-man crew is used. When the crew consists of only two men, one man uses the push rake and the other works on the stack. When there are three men, the third man drives the team on the stacker rope. With this method, the men at the stack are idle a large part of the time.

Three men will handle more hay if two push rakes are used and the push-rake operators drive the team on the stacker. A properly arranged small crew requires four men, or three men and one boy. This crew uses two push rakes, one man on the stack and one man or a boy to drive the team hoisting hay. Some types of stackers are automatic, while others require the services of an operator, which increases the size of crew and cost of stacking.

In extremely hot weather, or when the yield is very heavy, it is customary to use two men on the stack. When the yield is very light, say about half a ton per acre, one man on the stack can handle the hay brought by three push rakes.

MEDIUM-SIZED CREWS.

Medium-sized crews have from three to four push rakes, two to three men on the stack, and a driver for the stacker team. The amount of hay handled per day depends upon the number of push rakes used. A push rake will handle from 10 to 15 tons or more per day, depending upon the yield, size of team on rake, and skill of the driver.

LARGE CREWS.

Large crews consist of from five to seven push rakes, four men on the stack, one man to operate stacker or keep the hay cleaned up around the stacker, and one man or boy to drive team on the stacker.

The one point to be remembered is to make stacks of proper size. When small stacks are made, considerable time is lost in moving the stacker. When extra large stacks are made, there is a loss of time owing to the extra long haul with the push rakes. On many farms in the Middle West the 30- or 40-ton stack is a popular size when using large crews.

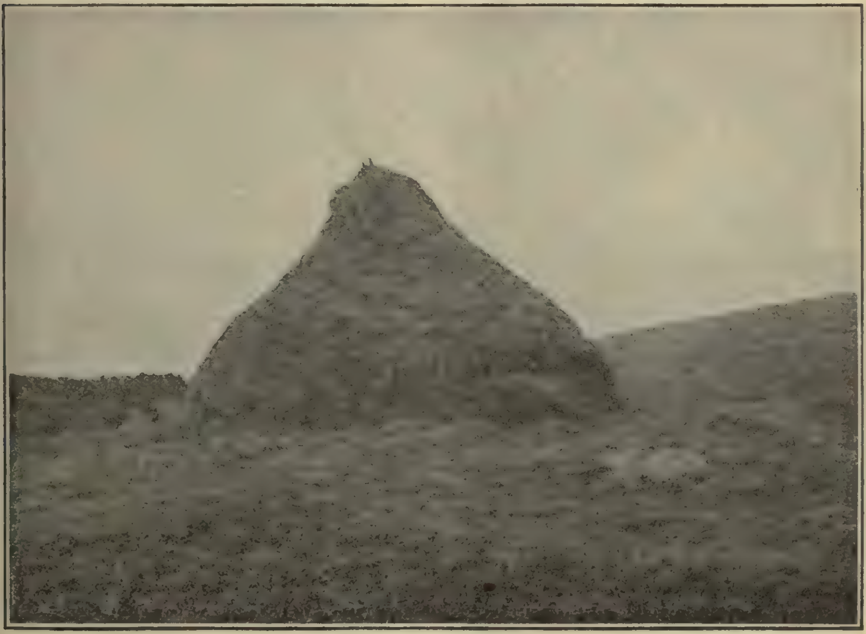

FIG. 13.—A very poorly built stack. The loss due to injury by rain will be considerable if the stack stands very long.

WHEN BALING IN THE FIELD FROM THE WINDROW.

This is undoubtedly the cheapest way of making hay that is to be baled. The economy results from saving the cost of stacking, that is, the cost of the crew that works on the stack.

SMALL CREWS.

When small crews are worked, the ordinary two-horse hay press is generally used. The ordinary crew, when the yield is 1 ton per acre, is made up of six or seven men. The work is divided as follows:

1 man and team mowing all day.
1 man and team raking with sulky rake half of the time.
1 man and team using push rake all day.
3 or 4 men and 1 team baling all day.

This crew will mow, rake, and bale an average of 10 tons per day. When the yield is half a ton per acre, two mowers and two push rakes will be required. The one sulky rake will rake all of the hay, unless it is the custom to rerake the field after the push rakes have taken the hay from the windrows. Reraking, or gleaning, is a practice that should be more generally followed, as many hay growers are of the opinion that the value of the hay gleaned will much more than equal the cost of the extra work.

FIG. 14.—Baling hay from the windrow with a two-horse press. Baling in the field is the cheapest method of handling the crop when it is necessary to bale. Well-cured hay and good weather are required to bale successfully from the windrow or cock.

LARGE CREWS.

When large crews are used, it is necessary to use a press with a greater capacity than the two-horse press. At present nearly all power presses are operated by gasoline engines, effecting a saving of two men (engineer and water hauler) over the steam press. The crew at the press usually consists of five men, two pitchers, two wirers, one feeder, and sometimes one man to bear away the bales. The ordinary crew will bale about 25 tons per day.

In some parts of the southern prairie hay section, where it is very hot during the hay-making season, there is a double crew of feeders and pitchers, who work in 30-minute shifts.

PLANNING HAYING OPERATIONS.

The haying season for tame hay lasts about 10 days. Sometimes, when the weather is unfavorable or the acreage is large, it takes longer to get the hay made. The hay grower should plan to get his hay made within two weeks at most, if possible. If the amount of hay each machine will handle per hour or per day and the amount of labor required per ton is known, plans can be made to make a certain amount of hay per day.

It has been found that, under average conditions, mowers, tedders, and sulky rakes will cover 2 acres per foot in width of the machine per 10-hour day. That is, a 5-foot mower will cut 10 acres per day, a 10-foot sulky rake will rake 20 acres per day, etc. One man can cock about 5 or 6 acres per day. A fair day's work for loading, hauling, and putting into the barn with a horse fork is about 5 tons per man.[1]

When the haying season comes, an effort should be made to make as much hay per day as possible. On many farms in the East the best results are not obtained, because hay is hauled only in the afternoon. This practice lengthens the haying season and thus increases the chances of damage to the hay from rain, and causes hay to lose its natural "tea green" color. The hauling crew should work all day, or at least start as soon as the dew is off, unless there is other more important farm work to be done.

FIG. 15.—Baling alfalfa and Johnson mixed hay in the South. The hay is cured in the cock and brought to the press with push rakes. The bales are hauled to the barn immediately to prevent injury from rain, which occurs frequently. This is the most economical method of making market hay.

Scarcity of labor will sometimes prevent the hauling crew from working in the morning, if the mowing, tedding, and raking are done in the forenoon.

When a crew is kept at the barn for unloading and putting the hay in the mow, the men should be kept busy all of the time, if possible. If a crew can not stay at the barn without considerable loss of time, the men should all work in the field, pitching, loading, or hauling, two or three coming in with each load to help unload.

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[1] For detailed information see U. S. Dept. of Agr. Bul. 412: "The Normal Day's Work of Farm Implements, Men and Crews in Western New York."

It is good practice to have only one day's mowing ahead of the crew hauling or cocking. Mowers, tedders, and sulky rakes should either be used all day or a full half day, whenever they work. In many methods of making hay, one or more of these machines will finish in the middle of the forenoon, and there will be no place for the men operating the machines to work at haying the remainder of the half day.

USE OF WORK CHART.

In planning haying operations, the method shown below will be found an easy way of keeping track of the men and teams and the length of time and amount of work each does during the day. Each man is represented by a capital letter and each team by a small letter.

With the method illustrated, only one man and team work in the morning. The mower runs from 7.30 until noon. In the afternoon, four men and four horses work. The rake is run from 1.00 to 4.00 o'clock, and the man and team on the rake do no other haying work the remainder of the afternoon. The three men that load, haul, and unload work a full half day in the afternoon, but put in no hay during the morning.

This crew could easily be managed so as to haul in hay in the forenoon, and thus double the amount of hay put away per day. A 6-foot mower would cut the right amount of hay for a day's hauling, and a 12-foot sulky rake would rake the hay in about half a day.

SOME APPROVED METHODS.

A few of the methods used by good haymakers are described below, to show how hay is handled under different conditions, and when different kinds of hay are made.

MAKING TIMOTHY AND CLOVER HAY, USING HAY LOADER.

The following method is used for saving the timothy and clover hay from 120 acres in central Iowa. The crew consists of seven men, three boys, and ten horses. One 6-foot mower starts between 8 and 9 o'clock in the morning, after the dew is off, and runs all day every day, mowing daily about 12 acres. When the yield is 2 tons per acre, one mower will cut enough to keep the hauling crew busy all day. If the yield is 1½ tons per acre, a second mower is used for half a day.

The hay is tedded after being in the swath one-half day, and raked with a side delivery rake the next day after being mowed. One man and team do the tedding and raking. When the crop is heavy, the side delivery rake is used to turn the windrows over an hour or two before the hay is hauled, so that the bottom of the windrow will be sufficiently cured.

Two teams and three wagons are used for hauling hay to the barn. Two boys are used to drive while loads are being put on. Two men work together loading the hay.

When the load reaches the barn it is left standing and the team returns to the field at once with an extra empty wagon. A boy is used for driving the team hoisting hay into the barn. Two men mow away the hay and one man remains at the barn all of the time to stick the hay fork while unloading.

The hauling crew start work at 7:30 o'clock in the morning and work 10 hours. This crew will average about 25 tons of hay per hay. This method of making hay can be used to advantage on farms where the haul is not excessive and 75 or more acres of hay are grown.

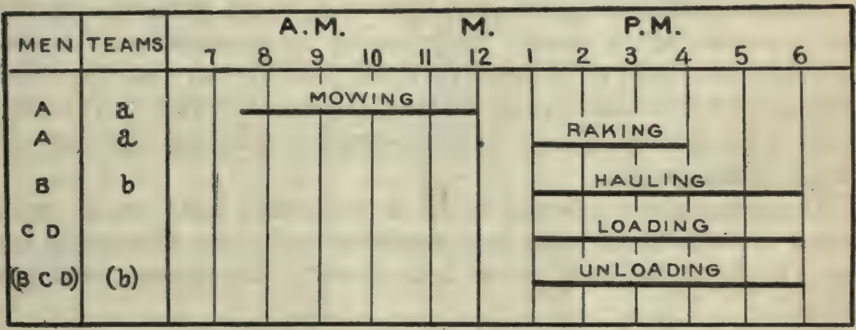

FIG. 16.—Work chart. Timothy and clover loaded with loader and unloaded with horses. Four men and 4 horses put up per day 6 tons from 6 acres. Yield, 1.0 ton per acre. Man hours 3.75, and team hours 2.08, per ton.

IRRIGATED ALFALFA PUT INTO THE STACK WITH PUSH RAKES AND STACKER.

In the irrigated sections of the West, haying crews usually work 10 hours a day. The following method is used by an alfalfa grower in Colorado in putting up alfalfa hay from 300 irrigated acres:

The crew consists of 10 men, 1 boy, and 18 horses. The men and teams work from 7 in the morning to 6 o'clock at night, with 1 hour out at noon.

Three 5-foot mowers cut 30 acres each day. One side delivery rake rakes 30 acres. Three push rakes are used, each handling 10 acres, or 10 tons per day. Two men are used on the stack, and a boy drives the team on the stacker. One sulky rake is kept busy all day raking, or gleaning, after the hay has been taken up by the push rakes.

The ordinary overshot stacker is used, and stacks 20 by 24 feet are built as high as possible. The stack sites are permanent and are used year after year. The push rakes tend to accumulate dirt around the stack, and this deposit of dirt prevents the stack site from being irrigated. When a later crop is put up, as much hay as possible is put on top of the earlier cutting, thus keeping down the number of stacks.

MAKING AND BALING PRAIRIE HAY.

The following method is used by a firm which makes and ships a large amount of prairie hay in the great prairie-hay section of the Plains States.

All of the work is under the supervision of a member of the firm who is in the field every day. Haying is begun the first of June and lasts until frost comes. Two presses are operated, having a combined capacity of 40 tons per day. One is operated by a 12-horsepower gasoline engine, and the other by a 10-horsepower steam traction engine. Four mowers, two sulky rakes, and four push rakes are necessary to keep the presses working to their full capacity.

The grass takes longer to cure in the early part of the season than in the middle of the season. Hay mowed in the morning of the first day is in condition to be baled by about 10 a. m. the next day, while that mowed later on during the first day can be baled in the afternoon of the following day. It is necessary to have one day's mowing ahead of the presses.

The grass is not allowed to lie in the swath until cured, but is raked with the sulky rake into windrows and there allowed to cure until ready to be baled, when it is taken to the presses with push rakes.

If considerable hay is partly cured by evening, it is raked, up to where the grass is freshly mown. This prevents the greater part of the hay from being wet by dew. Whenever possible, enough hay is bunched in the evening to allow an early start in the morning.

A little later on in the haying season, weather permitting, the grass that is cut in the morning will be cured enough to be baled in the afternoon. During the latter part of the year it again takes longer to cure hay, but as the hay is now of inferior quality, and contains a considerable portion of dead grass, it is not allowed to cure fully, but is baled rather green. The dead grass takes some of the moisture from the green, and thus prevents it from caking and molding.

In storing hay the bales are all placed on edge to allow the free circulation of air, which to a certain extent is a preventive of the hay becoming mow-burnt.

The hay made in the early and middle part of the season does not improve much while going through the "sweat," but late-cut hay that will not grade better than No. 2 the day it is baled will sometimes improve enough in color while passing through the "sweat" to grade as No. 1.

MAKING AND BALING ALFALFA HAY DURING UNFAVORABLE WEATHER.

The following extract[1] from a letter written by one of the most successful alfalfa growers in Alabama discusses his method of curing alfalfa in the cock:

We begin cutting alfalfa in the spring as soon as we find about one-half of the plants in bloom. We start the mowers as early in the morning as we can get to the field, regardless of dew, cloudy weather, or perhaps rain. In fact, we start the mowers even when a drizzling rain is falling and there is every indication of its continuing to rain. In that case the alfalfa lies on the ground until the sun comes out and cures it sufficiently so it can be raked into windrows. It frequently happens that early in the season, when the first crops are ready to cut, we have only a few days without rain; and unless we have the alfalfa cut and ready for the sun when it comes out, we would not be able to care for very much. Rain on the freshly cut, green alfalfa does not injure it materially; it is the rain that comes after it is partly cured that does the damage. For instance, on one occasion we had newly cut alfalfa lie in the swath for 10 days (the next crop having grown up through it) and then cure out and make hay that sold for $12.50 a ton.

As soon as the alfalfa is cured into a limp state it is raked into windrows and immediately pushed with a lift rake into piles of about 300 or 400 pounds each. These piles are then rounded into cocks and left to cure from 2 to 6 days, depending upon the weather. As soon as the hay in these cocks goes through a sweat, which is usually about the third day, the cocks from 8 to 10 acres are pushed with the lift rake to one place in the field, care being taken to place them from 8 to 10 feet apart, so that they can be opened and exposed to the sunshine.

Hay cured in this manner is usually ready for the press after being exposed to the sun for 2 or 3 hours, or when a handful of hay can be broken up by giving it three or four twists in the hands. In baling we have the tension of our press adjusted to the desired weight of bale, so that in tying there will be about 4 inches of space between the wire and the hay. As the bale is pushed out of the press it expands and the wire will tighten.

If more cured hay is ready for the press than can be baled before night, it is ricked and covered with a 12 ounce 20 by 30 foot canvas stack cover to protect it from the rain and dew. Such covers are also very useful for covering the baled hay in case of sudden showers, and will pay for themselves several times over in a season.

The baled hay should be set on end or stacked on edge (leaving a space between the bales for the circulation of air) and cross stacked. After a few days the bales can be restacked as desired.

We find that the great secret in getting our hay saved in proper condition is not to rake too green, and practical experience alone will enable the farmer to determine when the hay is in proper condition to rake. It is just about as detrimental, however, to let the hay cure too much or get too dry, as these conditions always result in the loss of a large per cent of the leaves by shattering.

The method used in making alfalfa hay in eastern Washington is described as follows:[2]

Object in view.—To get as large a percentage of the green crop into the stack just as green as possible without spoiling. This will give the maximum weight and quality of hay.

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[1] From a letter by C. T. Douglass.

[2] From a letter by C. E. Burlingame.

Method of making hay.—Cut when about one-fourth of the bloom is out. The time of cutting is not so important as the method of curing. The ideal time for making hay is when the weather is dry and when a brisk wind is blowing. The hay is cut with 5-foot mowers and raked with 10-foot rakes. The hay cocks most satisfactorily if the rake is made to take exactly two swaths of the mower. The rakes are started as soon as the hay is slightly wilted. This is very important, for there will be great loss of leaves and decrease in the weight of the hay if it lies in the hot sun for two or more hours after it is wilted sufficiently to rake. The rakes are driven around the field in the same direction as the mowers and the hay raked into medium-sized windrows.

The cocking is all done by hand. Each cock contains the hay of seven swaths, the aim being to cure the hay in compact large cocks. The hay of each swath is picked up separately and placed on the cock so that it flattens out into a layer. In placing the hay upon the cock it is never turned upside down, for the reason that this causes the leaves to fall out and tangles the hay up so that it will not pack together so closely. Large, well-proportioned cocks are built. The sides are raked down and the loose hay cleaned up well around the base. In finishing the cock, its top is pulled over toward the wind and pressed down so that it will not blow over. It is very essential that the hay be kept cocked up close to the rakes. The mowers and rakes are stopped and the men put to cocking if the mowers and rakes get more than three or four hours ahead of the cockers.

The hay is allowed to remain in the cock for at least four or five days. Small cocks are easily wet through to the ground during rains, while compact cocks that are raked down well turn the water and are wet in but a few inches. When hay is put up in this way, the bottoms of the cocks are sometimes damp, making it necessary to turn them over so that the sun can shine on the hay that was in the bottom of the cocks for two or three hours before being stacked.

The hay is stacked with sleds and slings. The size of the stacks is 30 feet square and 30 feet high. It is almost as important that the stacks be large as that the hay be cured in large compact cocks. A much greater percentage of the hay is ruined or damaged from bleaching, rain, and drying out in small stacks than in large ones.

PUPBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO HAYMAKING.

PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Cowpeas. (Farmers' Bulletin No. 318.)
Red Clover. (Farmers' Bulletin No. 455.)
Market Hay. (Farmers' Bulletin No. 508.)
Forage Crops for the Cotton Region. (Farmers' Bulletin No. 509.)
Crimson Clover, Utilization. (Farmers' Bulletin No. 579.)
Sudan Grass. (Farmers' Bulletin No. 605.)
Growing Hay in the South for Market. (Farmers' Bulletin No. 677.)
Field Pea as Forage Crop. (Farmers' Bulletin No. 690.)
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Wireworms Destructive to Cereal and Forage Crops. (Farmers' Bulletin No. 725.)
Natal Grass: A Southern Perennial Hay Crop. (Farmers' Bulletin No. 726.)
Minor Articles of Farm Equipment. (Farmers' Bulletin No. 816.)
Sweet Clover: Utilization. (Farmers' Bulletin No. 820.)
Harvesting Hay with the Sweep-Rake, Means by which Eastern Hay-Growers May Save Labor. (Farmers' Bulletin No. 838.)

PUBLICATIONS FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Forage-Crop Practices in Western Oregon and Western Washington. (Farmers' Bulletin No. 271.) Price, 5 cents.
Successful Southern Hay Farm. (Farmers' Bulletin No. 312.) Price, 5 cents.
Alfalfa. (Farmers' Bulletin No. 339.) Price, 5 cents.
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Timothy Production in Irrigated Land in Northwestern States. (Farmers' Bulletin No. 502.) Price, 5 cents.
Machinery Cost of Farm Operations in Western New York. (Department Bulletin No. 338.) Price, 5 cents.
Carrying Capacity of Grazing Ranges in Southern Arizona. (Department Bulletin No. 367.) Price, 15 cents.
Normal Day's Work of Farm Implements, Workmen, and Crews in Western New York. (Department Bulletin No. 412.) Price, 5 cents.
The Artificial Curing of Alfalfa Hay. (Bureau of Plant Industry Separate Circular 116.) Price, 5 cents.
Sudan Grass, a New Drought-Resistant Hay Plant. (Bureau of Plant Industry Circular 125.) Price, 5 cents.

CONTROLLING THE GARDEN WEBWORM IN ALFALFA FIELDS

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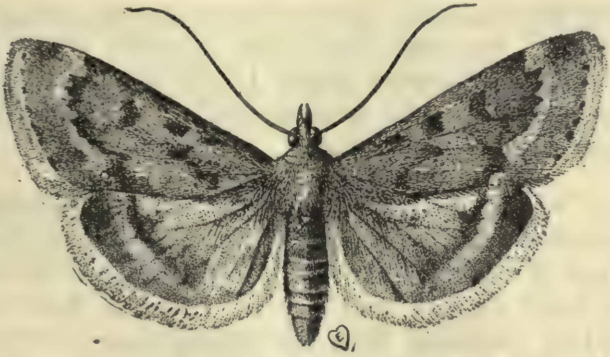

Parent of the Garden Webworm, Much Enlarged

FARMERS' BULLETIN 944

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. **Issued August, 1918**

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THE GARDEN WEBWORM, known as an enemy of truck crops, has become in recent years a serious alfalfa pest. In some cases second and third cuttings of the crop have been entirely destroyed. The insect has caused injury in the central western States, and there have been several serious outbreaks in Kansas and Oklahoma.

The worm or larva stage of the webworm is responsible for the injury to alfalfa. Properly timed cuttings of the crop will deprive these larvæ of their main food supply and expose them to heat and predatory enemies, thus destroying many of them and helping to decrease future damage.

Since the larvæ feed on several kinds of weeds, clean cultural methods and weed destruction are necessary in ridding alfalfa fields of the pest.

CONTROLLING THE GARDEN WEBWORM[1] IN ALFALFA FIELDS.

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HOW THE WEBWORM INJURES ALFALFA.

THE ALFALFA GROWER is not likely to observe the work of the garden webworm until his fields have been considerably damaged, as the first injury is done in the foliage nearly out of sight. The work is characteristic. The leaves are stripped from the stems and the plants are webbed together by dozens of small, black-spotted green and greenish-yellow worms or caterpillars which hide within the webs. These are the caterpillars or young of small, yellowish-brown moths which also are abundant in such fields. The presence of the web masses and moths and the greatly wilted appearance of the infested fields are sufficient to enable one, upon examination, to identify the cause of the injury readily.

WHERE DAMAGE HAS OCCURRED.

The garden webworm has been observed in most of the Central, Western, and Southern States. It also occurs in South America and Mexico. It has caused extensive damage to alfalfa in California, Nebraska, Iowa, Missouri, New Mexico, Kansas, Oklahoma, and Texas. In infested localities of the last three States it is not uncommon for second and third annual cuttings of alfalfa to be entirely destroyed by the pest.

Garden webworms were first noticed in injurious numbers in the central western United States in 1861 and 1864, when a considerable acreage of corn and garden crops was destroyed. In 1873 webworms caused much damage to beets, potatoes, garden crops, and other plants in the Neosha Valley, in eastern Kansas. In 1880 they appeared in large numbers in various crops over large areas in the Central West. In 1900 the first extensive injury to alfalfa was wrought by them in States west of and adjacent to the Mississippi River and in Texas. Again, in 1903 and 1904 serious damage occurred in Texas and Oklahoma to corn and cotton and to other farm crops in various localities in Ohio, Indiana, Nebraska, Kansas, and Oklahoma. In 1909 great damage was done to alfalfa in Kansas and Oklahoma. In 1911 and 1914, especially, severe outbreaks occurred during July and August in several localities in Kansas and Oklahoma. Since 1909 injury to alfalfa has become steadily more serious and widespread in the Central Western States.

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[1] *Loxostege similalis* Guenée; order Lepidoptera, family Pyralidae.

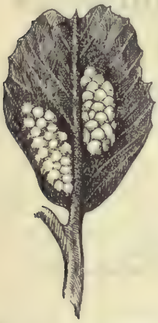

Fig. 1.—The garden webworm: Eggs. Much enlarged.

WHAT THE WEBWORM LOOKS LIKE.

The egg (fig. 1) is very small, oblong oval, and about one-fortieth of an inch in diameter. The eggs are deposited in a mass on the foliage of the plant, and are covered and held together by a thin, gelatinous fluid. They are so placed as partly to overlap one another, and the masses are almost transparent against the green background of the leaves, making them difficult of detection. When first laid the egg is of a delicate cream color, and remains so until about one day before hatching, when the coiled body and dark-colored head of the tiny larva within cause the egg to become slightly darker.

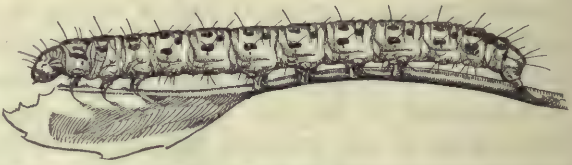

Fig. 2.—The garden webworm: Caterpillar or "worm." Much enlarged.

The larva, caterpillar, or webworm stage (fig. 2) is the one that causes the injury to the plant. When fully grown this larva is of a greenish-brown color and is about three-fourths to seven-eighths of an inch in length. Upon each body segment on each side of the back, arranged in triangles, are three tiny black spots, in each of which is inserted a short, stiff hair.

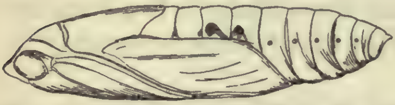

Fig. 3.—The garden webworm: Pupa or resting stage. Much enlarged.

The pupa or resting stage (fig. 3) is that into which the fully matured larva changes after descending from the plants to the ground and inclosing itself in a tiny silken cell in the trash and leaves on the ground or just beneath the surface. In this cell it transforms into a tiny light-brown chrysalis about three-eighths of an inch in length, cylindrical in the middle and tapering to a point at each end.

The adult is a small moth with a wing spread of about three-fourths of an inch. The color ranges from reddish brown to dark gray with varying darker and lighter markings on the wings.

SEASONAL HABITS.

In the course of its development this insect passes successively through the egg, larva, pupa, and adult stages. In the latitude of Kansas and Oklahoma the moths appear in the alfalfa fields about May 1. After mating they deposit their eggs, usually in clusters of 40 or 50, upon the lower surfaces of the leaves, usually those near the top of the alfalfa plants. These eggs hatch in about 4 or 5 days into tiny larvæ.

Soon after hatching these larvæ begin feeding upon the surface of the alfalfa leaves, and as they grow larger they web together the tops of the plants and feed upon the portions within the web masses until nothing is left of the plants except the skeletons of leaves and stems. After the more succulent parts of infested plants have been devoured the larvæ move to other near-by plants. If larvæ are present in a field in sufficient numbers an entire cutting of the crop may be ruined. An alfalfa field which has been badly damaged by this pest presents a scorched, withered appearance as if killed by frost. Many fields are injured only in irregular spots, these spots occurring usually on sandy upland. The larvæ also feed freely upon corn, wheat, careless weed or pigweed,[1] lamb's-quarters,[2] and a number of other plants. If disturbed they swing quickly from the infested plant on silken threads and endeavor to hide in the rubbish on the surface of the ground. They are very active, wriggling about rapidly if disturbed.

After about 20 days, when fully grown, the larvæ descend to the ground and form about themselves the tiny silken cocoons in which they change to the pupa or resting stage. During the pupa stage they remain inactive and take no food, although most remarkable internal changes in structure are taking place. The length of the silken cocoons, or pupal cells, depends upon the moisture and texture of the soil and the amount of trash about the plants. In loose sandy soil they are often slightly more than 1½ inches long, but in heavy, dry soil they usually are not more than one-half to three-fourths of an inch long. The cocoons are about three-sixteenths of an inch in length. They extend downward in a nearly vertical position, the top end even with the surface of the soil. After about 10 days the pupal case splits open and the tiny adult or moth issues from the top end of the silken cocoon.

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[1] *Amaranthus* spp.

[2] *Chenopodium album* L.

For several hours after emerging the moths do not fly but remain quietly waiting for the wings to become entirely expanded. They make only short flights, from 10 to 25 yards in length, when disturbed, and usually alight on the opposite side of the foliage from the pursuer. The distance the moths may fly is not known, although doubtless they may migrate several miles. They are most active at night, and are strongly attracted to lights. Individual females may deposit as many as 300 or 400 eggs. These eggs are placed on the alfalfa plants and on adjacent weeds. From 3 to 10 days elapse from the time the moths emerge until they begin to lay eggs. The moths live only a short time—sometimes only a few days. They feed upon the nectar in the alfalfa blossoms.

In the latitudes of Kansas and Oklahoma there are, apparently, four generations annually. The moths of the first generation appear about May 1, those of the second appear about July 10, those of the third about August 10, and those of the fourth about September 10. Individuals of the fourth, or of a possible fifth, generation may be present in the alfalfa fields for several weeks thereafter. The form or stage in which the insect overwinters in that latitude has not been definitely determined.

In the latitude of southern Texas the insects are present in the fields during the entire year. During the warmer months they complete all stages of their development in from 30 to 35 days, while during the cooler months the period of their development is somewhat longer.

NATURAL ENEMIES OF THE WEBWORM.

Enemies of several kinds prey upon and devour the larvæ of the garden webworm and assist to some degree in its control. The more efficient of these are common toads, horned toads, birds, and barnyard poultry, and certain species of ants and beetles. The common toad is probably the most useful of these, as stomachs of individual toads upon examination have been known to contain 70 or more webworms. Several parasitic enemies are also known to attack the larvæ of the webworm and may possibly assist in some degree in preventing its increase, as seven species of wasplike parasites and two species of flies have been reared from larvæ and pupæ.

Notwithstanding the helpful work of these natural enemies of the webworm, it would be unwise for the alfalfa grower to defer carrying out any active control measures in the expectation that some of these enemies eventually would subdue the pest, since this seldom occurs in time to save the crops.

HOW TO CONTROL THE WEBWORM IN ALFALFA FIELDS.

TIMELY CUTTINGS.

An excellent means of controlling the webworm in alfalfa fields is by properly timed cuttings of the several crops. When the alfalfa crop in an infested field has begun to get well into bloom, or when the young shoots have begun to appear near the bases of the plants, the cutting should be made as quickly as possible. Removal of the hay at this time will cause large numbers of larvæ to perish through lack of food and exposure to heat and predacious enemies.

It is a common practice of the farmers to cut any infested young alfalfa less than 6 inches in height as soon the pest is detected upon it. The hay from such cuttings has no commercial value, but its removal from the field deprives the larvæ of food and hastens their death. But the brush drag, described below, has been used successfully to kill webworms in alfalfa only a few inches high, thus saving the crop. Besides webworms, many other alfalfa pests are killed by the brush drag.

The alfalfa crop reserved for seed should be kept under careful observation, and in case webworms become numerous therein the crop should be cut immediately for hay. Unless such fields are carefully watched, the damage may increase rapidly and quickly render the crop practically worthless either for hay or for seed.

BRUSH DRAGS.

Brush drags have been found valuable after the cutting of infested fields to insure the destruction of a greater number of larvæ. An easily constructed drag may be made by attaching several short, tough branches of trees to one side of a strong timber 10 or 12 feet in length, propelling the drag by means of a team attached to the timber on the side opposite the brush. A piece of timber or other heavy weight placed on the brush is of value. With such a drag a large field may be covered in a short time. If necessary, heavily infested fields may be dragged twice without injury to the alfalfa plants.

CLEAN CULTIVATION.

Clean cultural methods are also of much value in controlling this pest. Since pigweed and lamb's-quarters are its favorite natural food plants, it is important that fields, fence rows, and near-by waste ground be cleared of these and other weeds. The pest often breeds upon such weeds and migrates later to near-by alfalfa which would escape injury if these weeds were not present.

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ERADICATION OF BERMUDA GRASS

ALBERT A. HANSEN
Scientific Assistant, Office of Forage-Crop Investigations

FARMERS' BULLETIN 945

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. September, 1918

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BERMUDA GRASS is one of the most valuable grasses and at the same time one of the most pernicious weeds in the Southern States.

It is perennial by means of the surface-creeping stems which enable it to spread rapidly during the growing season and to form the most desirable pastures and lawns.

The same characters which make it so valuable also render it one of the principal weeds whose eradication is essential to the successful growing of intertilled crops. This can be best accomplished by taking advantage of the natural weaknesses of the plant, which are (1) inability to withstand shade and (2) susceptibility of the rootstock to winterkilling.

The most widely practiced and successful control method, especially in the Southwestern States, is a combined attack upon these two weak points by alternating summer shade crops, such as velvet beans and cowpeas, with intertilled crops, such as corn and cotton, keeping the soil occupied with growing oats or rye, with or without vetch, during the winter.

Hogs also are useful in eradicating Bermuda grass. They are fond of the rootstocks, and they will be aided greatly in the good work if the land is first plowed. A good system is to graze the land an entire season, continue the grazing the following season until midsummer, then plow shallow to expose the rootstocks to the drying action of the sun and the persistent rooting of the hogs.

Bermuda grass may be winterkilled by exposing the rootstock system to freezing, but this method is effective only in the northern part of the Bermuda-grass area, as killing frosts do not ordinarily occur in the central and southern parts.

ERADICATION OF BERMUDA GRASS.

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IMPORTANCE OF BERMUDA GRASS.

BERMUDA GRASS is one of the most valuable as well as most troublesome grasses of our Southern States. This apparently contradictory statement is readily understood when it is known that Bermuda grass is one of the highest valued pasture and lawn plants in the South. The vigor and tenacity of the grass, which render it so valuable for forage and lawn purposes, likewise make it pestiferous when invading places where it is not desired, especially in such cultivated crops as cotton, tobacco, corn, and vegetables. Bermuda grass was at one time looked upon solely as a pest, but in view of the fact that it is exceedingly valuable for pasture, hay, and lawn purposes, the plant has been widely utilized throughout the cotton belt and its value is far in excess of the damage which it causes.

NAMES BY WHICH THE GRASS IS KNOWN.

Bermuda grass[1] is also known as "wire-grass," "reed-grass," "dog's-tooth grass," "salt-grass" (the common name in California), "scutch-grass," "cane-grass," "Bahama grass," "Yankee grass" (a local name in Virginia, because of its supposed introduction by the northern army during the Civil War), and "devil grass."

INTRODUCTION INTO THE UNITED STATES.

Bermuda grass is a native of the Bengal region of India. The time and manner in which it was introduced into the United States do not appear to be definitely known, but it was probably during the latter part of the eighteenth century. James Mease, in his Geological Account of the United States, published in 1807, states that "probably as important a grass as any for the Southern States is Bermuda grass, which grows with great luxuriance and propagates with astonishing rapidity by means of its numerous joints, every one of which takes root."

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[1] Among scientific workers three technical names have been used for Bermuda grass: *Panicum dactylon* L., *Cynodon dactylon* (L.) Pers., and *Capriola dactylon* (L.) Kuntze. The first of these names is now obsolete, while the latter two receive about equal sanction.

The present distribution of Bermuda grass is shown on the accompanying map (fig. 1).

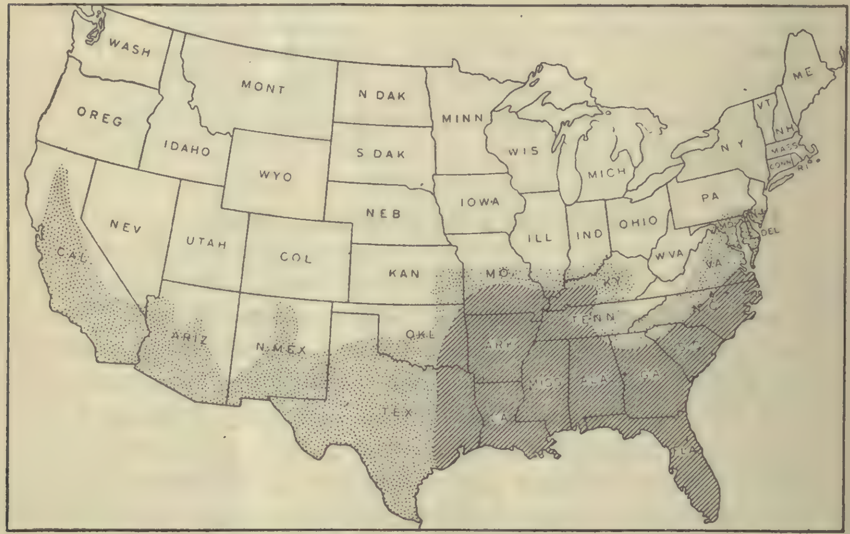

FIG. 1.—Present distribution of Bermuda grass in the United States, shown by shading. The heavily shaded area is the region in which the plant is most valuable.

IDENTIFICATION.

Bermuda grass is so well known that a detailed description is unnecessary. (See fig. 2.) Sometimes, however, the grass is confused with crab-grass,[1] goose-grass or crowfoot,[2] and water Bermuda grass.[3] It is distinguished from all of these plants, however, by the ring of white hairs at the base of each leaf blade. Another conspicuous characteristic of the plant is the mass of creeping stems or runners which it produces. It is by no means exceptional to find runners many feet in length, usually forming a matted growth, well adapted to withstand grazing and trampling. The combination of the creeping stems above the ground and of rootstocks immediately below the surface makes Bermuda grass pernicious when growing where it is not desired. From the creeping stems upright branches arise at intervals to a height of 6 to 12 inches, and sometimes taller. Each flowering branch is crowned by a cluster of three to five slender ascending spikes arranged like the rays of an umbrella. The stems of the grass are compressed and consist of numerous joints, each of which, if separated, may grow readily into a new plant.

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[1] *Syntherisma sanguinalis* or *Digitaria sanguinalis.*

[2] *Eleusine indica.*

[3] *Paspalum distichum.*

ADAPTATION TO SOIL.

Bermuda grass will grow on almost any type of soil, but it succeeds best on rich, heavy clays or clay loams. Upon such soils the plant is most noxious as a weed. It will make a moderate growth on clay soils which are too poor for the profitable production of most other crops. On sandy soils near the southern seacoast where the moisture is near the surface it is usually replaced by carpet grass.[1] Bermuda grass will tolerate more salt in the soil than probably any other of our common cultivated grasses. It is frequently found along seashores, where it proves resistant to the effects of salt-water spray. On the salt and alkaline soils of the Southwest it

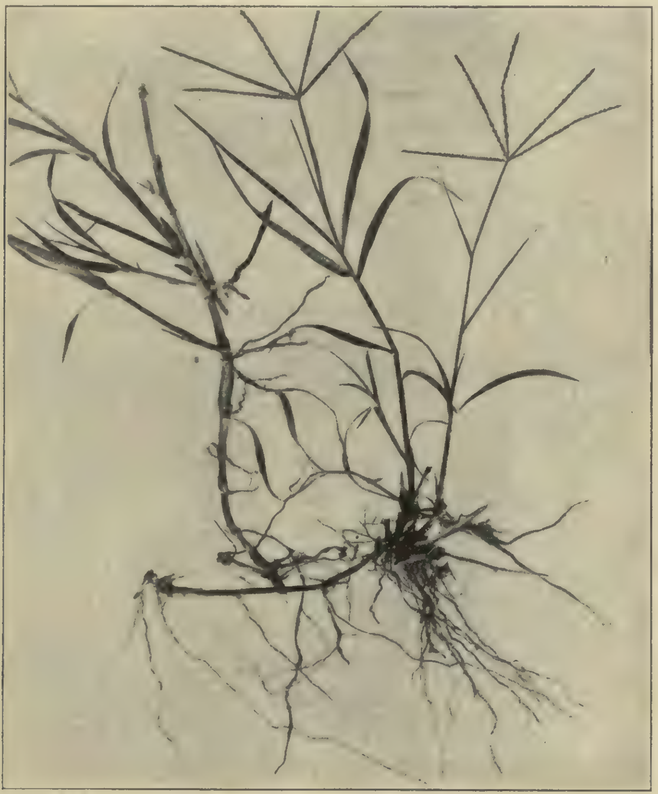

FIG. 2.—Plant of Bermuda grass.

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[1] *Axonopus compressus.*

will grow where most grasses fail. Occasional submergence by water does not seriously affect the vitality of the plant.

VARIETIES.

Aside from the common form of Bermuda grass, two well-marked varieties exist, both of which lack the underground rootstocks. Giant Bermuda grass[1] is coarser and taller than the ordinary variety, while St. Lucie grass is smaller and finer. The absence of underground rootstocks makes these two varieties easy to eradicate, and both are less resistant to cold, so that they do not survive the winter north of Charleston, S. C., and Montgomery, Ala. St. Lucie grass is preferred by many for lawn purposes because the lack of rootstocks renders it comparatively harmless.

In addition to the varieties here described, there are many other minor variations or strains, from which very desirable forms of Bermuda grass may be selected. Farmers will do well to keep on the lookout for new varieties or strains; when once found such new forms can be propagated readily by means of cuttings.

VALUE OF BERMUDA GRASS.

In any consideration of a plant which is more useful than harmful, the value should first be recognized. Bermuda grass is useful for the following purposes:

As a sod plant.—Bermuda grass is the most valuable of southern lawn grasses, forming a smooth, dense turf. The first winter frost will kill back this grass, giving the lawn a brown, lifeless appearance and thereby revealing the most objectionable feature of a Bermuda-grass lawn, more especially so in the northern portion of its range. This condition may be remedied by sowing Italian rye-grass seed in the early fall at the rate of about 20 pounds per acre. This rye-grass will quickly cover the lawn with a green carpet, which usually does not disappear until the Bermuda grass has become dense early in the following summer. No other grass has as yet been found which will successfully replace Bermuda grass as a turf plant on moderately heavy and fertile soils in the sections of the South where Kentucky bluegrass or the bent grasses can not be advantageously grown. South of the Piedmont area the last two grasses can be grown only with special care. Bermuda grass is used extensively in making the sod of golf courses and grass tennis courts.

As a pasture plant.—Bermuda grass is the leading permanent pasture plant of the South; for this purpose it is used either alone or mixed with lespedeza. By the addition of black medic or bur clover the pasture may be grazed throughout the year. When used for pasturing, the land must be plowed or disked every few years because of the tendency to become sod bound. The underground parts are greatly relished by hogs.

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[1] Technically termed *Cynodon dactylon* var. *maritimus.*

As a hay crop.—In a limited part of its range and upon rich soils only, Bermuda grass is used for hay purposes, especially on bottom land where a sufficient height is attained by the plant. As a hay crop the grass should be cut early, since overripe Bermuda hay is of inferior quality. Normally two crops are produced in a season.

Soil binding.—Wherever soil erosion is a problem Bermuda grass is found useful to bind and catch the soil. Many southern levees are kept intact by means of a carpet of this grass. Shifting sands may also be arrested by its use, and sloping fields may be saved from erosion by well-set stands.

A very important use of Bermuda grass is to assist in the filling of gullies. Its creeping habit enables the plant to cover the soil; once established, the grass holds with great tenacity. The creeping stems, furthermore, are well adapted to holding particles of earth washed by rains. As the gully is thus built up, the Bermuda grass rises with the added soil. The dense mat of grass permits little loss of soil during this process.

Seed production.—Bermuda grass normally produces an abundance of viable seed in but a small part of its range. In the seed-producing areas, however, a source of considerable profit is thus opened. Prolific seed production is common in New Mexico, southern California, and Arizona; in these States seed raising is a profitable industry. American-raised seed is superior to the variety imported from Australia, which was formerly the main source of supply. The plant probably matures seed throughout its entire range, but the quantity of perfect seed normally formed is very small except in semiarid regions. For more humid States viable seed has been definitely recorded from Pennsylvania, the District of Columbia, North Carolina, Mississippi, Louisiana, and Texas.[1]

BERMUDA GRASS AS A WEED.

Although in many respects one of the most valuable forage plants of the South, Bermuda grass often causes much trouble as a weed. The greatest damage inflicted by this weed is in such cultivated crops as cotton, corn, tobacco, and vegetables. It is said that before the true value of the grass was appreciated many infested plantations and farms were abandoned because of its presence.

Where not desired in lawns Bermuda grass is objectionable, especially in regions favorable to the growth of bluegrass. On bluegrass lawns patches of Bermuda grass become brown when cold weather arrives, thus marring the beauty of the sward. Furthermore, the invasion of gardens by the grass necessitates much labor in order to clear the land of the undesired plants.

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[1] Propagation methods, cultural directions, and other information are presented in Farmers' Bulletin 814, "Bermuda Grass," by Samuel M. Tracy.

MEANS OF DISSEMINATION.

One of the most important features in the control of any noxious weed is to prevent its introduction into noninfested areas. The methods of dissemination have much to do with rendering a plant troublesome, since a weed easily distributed will again readily invade an area from which it has been cleaned out. Bermuda grass may be distributed by various methods, as follows:

Seed.—Though not many viable seeds are matured in humid regions, enough are perfected to make them a noteworthy means of distribution. They may be disseminated in a variety of ways, the most important of which are probably in hay, by floating in streams, and by transportation in mud adhering to wagons and other agricultural implements, and on the feet of animals.

Creeping stems upon the surface of the ground.—By its creeping stems (see fig. 2) a single plant may cover considerable ground in the course of a season of growth. This type of distribution is entirely local.

Creeping rootstocks below the surface of the ground.—The creeping rootstocks of the grass are likewise important in causing local distribution.

Detached pieces of either the creeping stems or the rootstocks.—These may be distributed by becoming attached to plows, wagons, and other farm implements. In addition, pieces may become lodged between the hoofs of cloven-footed animals and thus transported from place to place. Furthermore, certain birds, of which the orchard oriole is an example, use Bermuda grass in the construction of their nests and in so doing aid in distributing the plant by scattering small pieces of the rootstocks.

METHODS OF ERADICATION OR CONTROL.

The best way to eradicate a plant is to take advantage of its natural weaknesses.

The most vulnerable characteristics of Bermuda grass are (1) that the rootstocks are unable to withstand exposure either to intense cold or to severe drying and (2) that the plant can not endure prolonged shading.

ERADICATION BY COMBINING SHADE AND INTERTILLED CROPS.

Bermuda grass does not thrive except in open places and can not resist the effect of prolonged shade. This makes it relatively easy to bring the weed under control by smothering it with heavy-growing or shade crops alternating with intertilled crops.

Many of the rootstocks may be removed after shallow plowing by harrowing or raking. This process entails additional labor but assists materially in subduing the weed.

The summer shade crops best suited for the eradication of Bermuda grass are velvet beans and cowpeas, although any other shade-producing plants, such as soy beans, sorghum, and millet, may be used. On poor soils velvet beans are the most efficient. Shade crops should be heavily seeded. The following crop should be winter oats or rye, either with or without vetch. After the removal of the oat or rye crop an intertilled crop, usually corn or cotton, should be planted. When the intertilled crop is removed the Bermuda grass will have been eradicated, provided the tillage was thorough. If the weed has not been eradicated, the entire process may readily be repeated, since by so doing there is no loss of the use of the land. An additional advantage of this combination method is that no organic matter is lost to the land.

In case the land is in Bermuda-grass sod, it may be plowed either in the fall or in the spring. If plowed in the spring, plant the summer shade crop and continue as previously suggested. If the land is plowed in the fall, plant the winter crop, follow by a summer shade crop, then another winter crop, after which the land should be practically free of the weed and ready for the intertilled crop.

The success of the method combining shade and intertilled crops depends on having the crops follow each other in such close succession that there will be no intervals during which the Bermuda grass will have a chance to spread, as it will quickly reestablish itself under favorable conditions.

ERADICATION BY WINTERKILLING.

Bermuda grass can not withstand severe cold. This weakness may be counted on to secure its eradication in the northern limits of its range or in any locality where prolonged periods of cold are experienced. The thick, matted rootstocks should be plowed shallow in the fall, thereby exposing them to winter freezing. A single severe freeze will often almost completely destroy the grass in a field so treated.

In plowing, it should be remembered that the rootstocks are usually close to the surface, especially when the field has been grazed. In consequence, very shallow plowing is necessary. The depth of the furrow should not exceed 2 or 3 inches. (See the illustration on the title-page.) Plowing can most readily be accomplished by using the type of plow known as the "Scotch bottom," an implement designed for turning a furrow of sod completely over.

Another method of securing winterkilling is repeated disking, cross disking, and harrowing during the winter season. The winterkilling method conserves the organic matter contained in the weed growth.

ERADICATION BY COMBINING FALLOWING AND INTERTILLED CROPS.

A cultivated field seriously infested with Bermuda grass may sometimes have to be abandoned for a season as far as crops are concerned while control methods are being practiced. The following method is applicable only to regions that have dry summers, such as the semiarid regions of the Southwest, and should not be used in regions with moist summers.

The best results are obtained by fallowing if the following procedure is adopted: First, utilize the grass for an entire season either for hay or pasture. Toward the end of the season the wiry, tangled rootstocks will have formed a dense mat immediately below the surface, or, in other words, the field will have become sod bound. In this condition the grass is most readily destroyed. Continue grazing the following season until midsummer, then plow shallow with a sharp turning plow, cutting off the furrow slice clean and turning it completely over. Deep plowing is beneficial rather than harmful to the grass; hence, the furrow should not exceed 3 or 4 inches in depth. A great deal of the rootstock system can be removed by means of raking, and this may sometimes be practicable. The exposure of the rootstocks to the hot sun will destroy a great proportion of them. The land should then be disked during the remainder of the growing season at intervals frequent enough to keep in check any top growth of the grass. The drying influence of the sun, combined with the starvation caused by the prevention of green growth, will often result in a complete destruction of the Bermuda grass in a single season. This method is most effective during a dry period and may not be successful during a season of continuous rainfall. In the southwestern portion of the Bermuda-grass area a winter cover crop also will be found valuable in this connection.

The following season an intertilled crop, such as corn or cotton, may be profitably planted, so that the consequent cultivation may destroy any stray Bermuda-grass plants which have survived.

A modification of this plan is practiced successfully in California. The infested land is pastured closely during the spring and plowed very shallow in early summer or as soon as the ground has dried out. The land is then thoroughly disked, immediately after which the spring-tooth harrow is used in order to drag out the pieces of grass and bring them to the surface. This harrow is used every other week until fall, when the land is plowed deep and planted to a winter crop. An intertilled clean-up crop is grown the following spring in order to destroy any Bermuda-grass plants which have survived.

ERADICATION BY GRAZING WITH HOGS.

On light sandy soils hogs are sometimes used to dig up the rootstocks, which they eat greedily. Plowing will greatly aid the animals to get the rootstocks. The hogs, of course, should not have their snouts ringed.

ERADICATION METHODS FOR SMALL AREAS.

On small areas the following method is effective: Plow shallow to a depth of about 3 inches during a midsummer period of dry weather, turning the matted rootstocks to the sun as much as practicable. They should remain exposed until the entire surface is well dried out, a process which will be aided greatly by stirring the mass of plowed-up rootstocks every few days with a spading fork, rake, or spring-tooth harrow.

When the mass is thoroughly dry it may be raked into piles and burned or else removed to waste places. This method is laborious and has the disadvantage of wasting the organic matter contained in the grass.

In such limited areas as gardens the rootstocks can be gathered up with a rake or fork and burned. Another method which has been successfully used for small patches is to cover the infested spots in summer with tarred or other heavy paper in such a manner that the light is entirely excluded. The edges of the paper should be overlapped and covered with soil and the entire area of the paper well weighted down with soil or stones. In about two months it will be found that the Bermuda grass is entirely killed.

"YOU WILL REALIZE, as I think statesmen on both sides of the water realize, that the culminating crisis of the struggle has come and that the achievements of this year on the one side or the other must determine the issue. It has turned out that the forces that fight for freedom, the freedom of men, all over the world as well as our own, depend upon us in an extraordinary and unexpected degree for sustenance, for the supply of the materials by which men are to live and to fight, and it will be our glory when the war is over that we have supplied those materials and supplied them abundantly, and it will be all the more glory because in supplying them we have made our supreme effort and sacrifice."—*From President Wilson's Message to Farmers' Conference at Urbana, Ill., January 31, 1918.*

CARE AND REPAIR OF FARM IMPLEMENTS

No. 3

PLOWS AND HARROWS

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FARMERS' BULLETIN 946
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Office of Public Roads and Rural Engineering
LOGAN WALLER PAGE, Director

Washington, D. C. March, 1918

Show this bulletin to a neighbor. Additional copies may be obtained free from the Division of Publications, United States Department of Agriculture

THIS bulletin, dealing with the care and repair of plows and harrows, is one of a series to be issued by the Department of Agriculture. Others of the series will deal with the care and repair of mowers, reapers, and binders, farm shop and equipment, farm shop practice, and other farm implements.

Thoughtlessness in the handling, care, and repair of farm machinery results annually in the loss of many thousands of dollars and much time to farmers. At this time every minute should be made productive of some result and every dollar should be saved.

This series is published to aid the farmer in preparing his machinery for the season's work at a period when he has time to do so and to minimize delays and loss of time in the field.

CARE AND REPAIR OF FARM IMPLEMENTS.

No. 3. PLOWS AND HARROWS.

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PLOWS.

PROBABLY no implement used on the farm receives a greater measure of abuse or as little attention to its proper care, operation, and repair as the plow. To quote a recent writer on machinery:

> The plow is the basic tillage tool, the fundamental farm implement. It is not merely a tool for inverting the furrow slice, but it is the most efficient pulverizer of the soil in use. As the moldboard turns the furrow, each particle of soil is forced to slip against the particle adjoining, a process which results in a tilth that no other single operation approaches. The general impression prevails that the plow is a simple tool, requiring but little adjustment and less care. This is far from the truth, however. Without question it is the most complex tool on the farm, in that it requires the greatest skill for adjustments, the grain-binder and the gasoline engine not excepted. More effort has been expended in the slow process of development of this seemingly simple tool than in that of any other implement on the farm. Careful study of its construction, adjustment, and use will be amply rewarded.

This useful implement should not be allowed to remain in out-of-the-way places subject to deterioration by weather conditions, but should be housed properly when not in use. When laid by, it should be stored in a dry place away from contact with the ground and the bright parts coated with grease to prevent rust. Once the moldboard share and landside have become pitted with rust an efficient job of plowing can not be done until the corroded parts again have acquired a polish by use. In overhauling, the following scheme is suggested:

HAND PLOWS.

REPAIRS.

FLATLAND PLOWS.

Share.—If chilled cast iron and badly worn, renew. If steel and badly worn, should be sharpened, bearing at wing ¾ inch for 10-inch bottom to 1¼ inches for

16-inch bottom; vertical suction, ⅛ inch; horizontal suction, ⅛ to ¼ inch, as shown by figure 1.

Landside.—If badly worn and detachable sole is provided, replace sole, otherwise it will be necessary to renew landside.

Moldboard.—Usually in two parts, shin and moldboard proper. If shin be present and badly worn, renew. See that moldboard is bolted tight to frog.

Bracing.—If loose, tighten up connections.

Handles.—If loose, tighten up bolts so that they are attached rigidly to bottom and see that bracing is tight.

Beam.—If loose, see that bolts to frog are tight.

Gauge wheel.—Examine bearings and if badly worn replace with new. If plain bearings, do not lubricate. See that gauge-wheel standard is bolted rigidly to beam.

Jointer.—Examiie point, if badly worn and if chilled cast iron, renew; if steel, it may be sharpened. See that it is bolted rigidly to the beam.

Rolling coulter.—Seldom used on hand plows but if present examine the coulter-wheel bearing and if badly worn, renew. See that the standard is attached rigidly to the beam.

Fin or hanging coulter.—Should be attached rigidly to the beam and sharpened if worn.

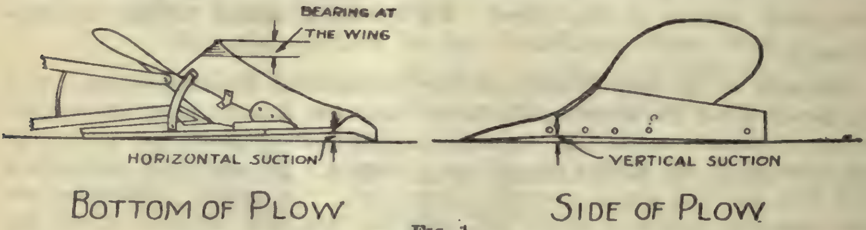

FIG. 1.

HILLSIDE PLOWS.

In addition to points considered in connection with flatland plows, examine hillside plows for the following:

Swivel joints.—These should work freely, but have little lost motion. If adjustment be provided for, take up lost motion; otherwise renew bearings.

Latch.—Should catch and hold moldboard tightly against standard.

Jointer.—Should reverse automatically when moldboard is swiveled. If it reverse too far in one direction and not enough in the other, adjust to mid-position.

Clevis shifting lever.—See that this lever latches properly in required positions.

Suction.—Some hillside plows are equipped with shoe on the landside by means of which vertical suction may be regulated.

ADJUSTMENTS.

Depth of furrow.—Made by raising or lowering the clevis or bridle on end of beam. This also may be regulated slightly by the gauge wheel where wide and frequent variations in soil conditions prevail. The gauge wheel should not be used where the soil conditions are uniform, except in very stony soil, as it increases the draft of the plow. In any case, there should not be excessive bearing pressure on the gauge wheel, the function of this wheel being to prevent plowing at a greater than the desired depth when passing from a firm and hard soil to one of more friable nature.

Width of furrow.—Made by shifting the hitch on the clevis or bridle to or from land according to whether a greater or less width of furrow slice is desired. In using more than two horses this also may be regulated to some extent by the gauge wheel if this wheel has a standard which may be adjusted to lead wheel to or from land.

Handles.—Should be adjusted to suit height of the operator.

Jointer.—Should be set so that its point is just above or just back of the point of the share, to run 1½ to 2 inches deep and slightly to the landside of the shin of the plow.

Coulter.—If used, it should be set in a position similar to the jointer except that it should run about half the depth of the furrow. A rolling coulter does not, however, take the place of a jointer. The functions of the two attachments differ in that the function of the jointer is to turn under a small furrow slice ahead of the furrow proper, so that a smoother job of plowing results, and that of the rolling coulter to cut tough grass roots and surface trash, so that they may be covered more efficiently by the furrow slice.

Hitch.—The theoretical line of draft originates at a point about 2 inches from the moldboard side of the shin, just above the junction of the shin and moldboard. This line should pass through the hitch at the beam clevis and end at a point midway between the short tug rings at the hames. Any variation from this line will influence the plowing, such as too short or too long traces, short hip straps, etc. If this line be straight and the reins adjusted properly, the plow properly set for depth and width required, no effort of the operator is needed in guiding, except to steady the plow in a proper running position when obstacles are encountered.

SULKY AND GANG PLOWS.

REPAIRS.

Wheel bearings.—Take down, clean with cloths saturated with kerosene oil, make adjustments for wear if provided for, and repack with heavy grease before assembling.

Frame.—Examine for loose bolts and connections and take them up.

Landing and lifting levers.—See that all connections are tight and take up lost motion if possible.

Beam and frog.—Examine for loose bolts and connections and tighten if present.

Share.—If worn, replace or sharpen.

Landside.—If worn and has a removable sole, replace the sole, otherwise replace the landside.

Coulter.—Rolling coulter usually is used. Examine the bearings and renew if necessary. See that the coulter standard is attached rigidly to the beam.

ADJUSTMENTS.

Depth.—Regulated by raising or lowering the bottom in relation to the frame. Suction as applied to sulky or gang plows is the distance of the back end of the landside from the floor with the point and wing of the share resting on the floor. This is about one-half inch for most plows, though it may vary for different lengths of landsides.

Width.—Regulated by adjusting the hitch to or from land on the frame. It may be regulated also to some extent by "landing" the front furrow wheel.

Jointer.—If used, it should be set so that its point is just above and just back of the point of the share, to run 1½ to 2 inches deep and slightly to the landside of the shin of the plow.

Coulter.—Should be set half the depth of the furrow, back of the point of the share and slightly to the landside of the shin. If used in connection with a jointer, it should be set ahead of it.

Wheels.—The land wheel should travel directly to the front of and parallel with the furrows. The front furrow wheel is given a small lead from the land, likewise the rear furrow wheel. The rear furrow wheel should run 1 to 2 inches outside of the landside of the plow.

Hitch.—In any wheel plow the load should be carried on the wheels as much as possible to reduce the draft. The driver may test this by dismounting while the plow is under way and taking hold of the frame at the front wheel and sliding it sidewise, and doing likewise at the rear furrow wheel. If equal resistance to side motion be encountered, it is reasonable to assume that all the load is carried on the wheels. The load may be equalized by raising the point of the hitch or lengthening the traces.

DISC PLOWS.

The general features of disc plows are the same as in other plows except that the bottoms are replaced by discs.

Repairs.

Refer to sulky and gang plows and examine:

Disc bearings.—Take down, clean with kerosene, replace the worn parts, and assemble with sufficient grease to pack the bearings properly.

Discs.—Sharpen or replace if badly worn.

Scrapers.—See that all connections are tight and if the scrapers are badly worn, renew them.

Adjustments.

Depth of cut.—Is regulated by raising or lowering the frame, to which the discs are attached, on the staff bearings of the front and rear furrow wheels and land wheel.

Width of cut.—Is regulated by landing the front and rear furrow wheels and setting the scrapers for a wide or narrow furrow.

Wheels.—The land wheels should travel directly to the front and parallel with the furrow. The front furrow wheel is given a small lead from the land, likewise the rear furrow wheel, which should run 1 to 2 inches outside of the land side of the furrow.

Hitch.—In any disc plow, loads should be carried on the wheels as much as possible to reduce draft. The load may be equalized by raising the point of the hitch or lengthening the traces.

HARROWS.

As the plow is the basic tillage tool, it follows that the harrow plays the next most important part in the preparation of the soil for the seed. From the first harrow employed, the old-time wooden

"A" frame drag with square teeth, have developed the three classes, spike-tooth, spring-tooth, and disc harrows, now mainly used.

The care and repair of these implements will be discussed in the order mentioned.

SPIKE-TOOTH HARROWS.

In overhauling, the following procedure is suggested:

Frames.—Examine in detail to see that all frame bolts are tight. Bent or distorted frames should be restored to their original shape. Broken or bent frame bracing should be replaced or restored to its original shape and broken connections replaced.

Teeth.—If worn on one side only, should be reversed in the clamps. If dull and blunted, they should be removed and resharpened by forging and retempering. When replacing teeth, support the frame equally all round on a floor or flat surface and set teeth to a uniform depth. See that all clamps are drawn up tight, but not so tight that threads are stripped or bolts stressed to the breaking point. All lock nuts and cotter keys should be in place, and broken or bent bars replaced or straightened. Wooden tooth bars should be scraped clean of earthy accumulations, brushed, and painted.

Lever connections.—Examine lever connections to see that they work freely and latch positively. Straighten bent levers and put cotter keys in lever connections in place. Renew any broken or badly worn parts.

Draft connections.—The drawbar, if of metal and bent, should be straightened and also the bails. If drawbar and bails are bent the teeth will track, and good work can not be obtained. Toggle bolts and links, if badly worn, should be renewed and all nuts drawn up tight.

Storage.—Many farmers who would not neglect an expensive harvesting machine are careless in the care of harrows and other implements of this type. These also represent capital invested, and a larger return is possible if they be properly cared for and housed at the end of the season. If stored under a shed the teeth should be supported by blocks or boards so they will not become embedded in the ground. All accumulations of earth and trash should be removed. Especially is this true of wooden frame harrows. The earthy accumulations retain moisture and accelerate decay of these parts. If these parts have dried out sufficiently they may be painted, which will prevent season checking and splitting. As the harrow works in wet earth close to the ground, once checking has started the deterioration is rapid, especially at those points where metal and wood come into contact. Aside from prolonging its usefulness and adding to its appearance, a well-cared-for implement which retains some of the appearance of newness commands more respect and is subject to less abuse from the operator than one which has the general atmosphere of decrepitude.

SPRING-TOOTH HARROWS.

Spring-tooth harrows differ from spike-tooth harrows in that the short, straight, rectangular steel-spike tooth is replaced by a flat piece of spring steel, conforming more or less throughout its length to the arc of a circle and having a flat point forged on one end or equipped with a reversible point. Special teeth with round points are also made for harrowing alfalfa fields. The spring-tooth harrow finds its widest use in those sections where deep cultivation is desired and stony land abounds.

Much that has been said about spike-tooth harrows applies to the spring-tooth type as well. Such headings as differ and have not been touched upon in the foregoing outline follow:

Teeth.—Teeth, when dull, should be sharpened unless equipped with reversible points. In sharpening by forging, the original form of point and temper should be maintained.

Shoes.—Some makes of harrows have individual shoes at the junction of the harrow tooth and frame to prevent wear of the tooth at this point. If worn, these should be renewed.

Wheels.—Some makes of harrows carry the weight of the frame and teeth on wheels with or without a riding seat. For such harrows, examine wheel boxes and bearings and renew badly worn parts. Examine seat fastenings to see that all connections are rigid and tight.

Riding attachments.—Riding attachments have come into use in later years. These add little to the draft and make available for this work labor which otherwise could not be used. Plodding behind a harrow on soft ground is hard work and requires a sturdy constitution, especially if there is any considerable acreage to be cultivated. These attachments are used with spike-tooth harrows also. In overhauling, examine seat and frame connections to see that they are rigid and tight, and also the wheel bearings, replacing any parts worn or weakened by wear.

DISC HARROWS.

Disc harrows are used both before and after plowing. The advantages claimed for use before plowing are that surface trash is cut up so that it is covered more efficiently by the furrow slice, and that the top soil is pulverized so that less draft is required in plowing, also that this pulverized soil is turned into the bottom of the furrow, so that the soil particles lie close and in more intimate contact and better retain moisture. This harrow is used in both single and double disc gangs. The advantages claimed for the double-disc gang is that it both pulverizes and levels the ground in one operation, the front gangs being set to throw the soil out, the rear to throw the soil in. The rear gang also has an opportunity to break up the clods while they are still soft when stirred up by the front gang. This assists in preventing moisture evaporation. In overhauling disc harrows the following procedure is suggested:

Main frame.—Examine frame connections to see that all bolts are tight and that gang bearings and frame bracing are attached rigidly. Bent or broken frame bracing should be straightened or replaced.

Gang bearings.—Examine and wash out grease and dirt with coal oil or gasoline and wipe dry. Worn parts should be renewed. Unless they are dust tight, bearings on disc harrows show wear more quickly than any other part. If wood bushings are used, a supply should be on hand to replace those worn, as they are inexpensive. See that oil pipes are cleaned out and that grease or oil gets down into the bearings. If grease cups are used, see that they are screwed down sufficiently to insure a supply of grease in the bearings. In replacing, pack bearings with grease. If this is not done, it will be necessary to fill the grease cups and screw them down two or three times to insure proper packing of the bearing.

Discs.—Discs should be sharpened if dull so that they cut trash and penetrate the ground readily.

Disc gangs.—See that the discs are tight on gang bolts. If they are not, the discs will wobble and good work will not result.

Bumpers.—When disc gangs are set at an angle for discing see that bumpers come in contact with each other and carry all end thrust off the boxes and bearings, thus prolonging their life.

Scrapers.—Examine scrapers and replace any badly worn. See that all bear equally on the discs. If any are too close, they will cause friction and wear; if too far away, they will not clean discs properly.

Snubbing blocks.—Examine to see that they are adjusted to keep gangs running level when in use. If gangs are cutting too deep in the center, raise the snubbing blocks, so the gangs will run level. If gangs are running too high in the center, lower the snubbing blocks.

Levers and quadrants.—See that levers work freely and positively and that all attachments are bolted securely to the stub tongue bracket. Worn or broken parts should be replaced.

Seat and draft connections.—See that all fastenings are tight. A seat insecurely fastened may cause trouble if double gang is used. Draft connections, if badly worn, should be renewed.

Adjustments.—There are few adjustments to make on a disc harrow in the field. Depth of penetration is secured by angling the discs according to the hardness of the soil. When lapping, the gang that is working the ground previously disced should be set at a greater angle than the one working the undisced land. The harrow will run straight and side draft will be eliminated. When discing on side hills the gang on the uphill side should be set at the greater angle so that the tendency to work downhill will be overcome. On wet soil the scrapers should be used frequently to prevent clogging of the discs. If a tongue truck is used it should be adjustable for different heights of team and different depths of discing so that the truck is not forced into the ground, thus increasing the draft.

Storage.—At the close of the season or when the disc harrow is not in use, if stored under a shed, the disc gangs should be run upon boards so the discs may not become embedded in the ground. The implement should be cleaned carefully of all accumulations of soil, and discs greased with a heavy grease to prevent rust. The protective covering of paint should be renewed at the proper time. Especially is this true of the wooden parts.

Transporting.—When transported long distances disc harrows should be carried in a wagon or other vehicle. Transport trucks, wheels, rollers, or other means should be provided for moving a disc harrow over roadways about the farm. A plank float may be used for this purpose.

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CARE AND REPAIR OF FARM IMPLEMENTS

No. 4

MOWERS, REAPERS, AND BINDERS

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FARMERS' BULLETIN 947

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Office of Public Roads and
Rural Engineering

LOGAN WALLER PAGE, Director

Washington, D. C. March, 1918

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THIS bulletin, dealing with the care and repair of mowers, reapers, and binders, is one of a series to be issued by the Department of Agriculture. Others of the series will deal with the care and repair of plows and harrows, farm shop and equipment, farm shop practice, and other farm implements.

Thoughtlessness in the handling, care, and repair of farm machinery results annually in the loss of many thousands of dollars and much time to the farmer. At this time every minute should be made productive of some result and every dollar should be saved.

This series is published to aid the farmer in preparing his machinery for the season's work at a period when he has time to do so and to minimize delays and loss of time in the field.

CARE AND REPAIR OF FARM IMPLEMENTS.

No. 4. MOWERS, REAPERS, AND BINDERS.

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NEED OF ATTENTION TO IMPLEMENTS.

UNDOUBTEDLY many mowing machines have been or are about to be scrapped though still capable of doing several years of useful work if only a small percentage of their original cost were expended upon them for repairs. The proper time for overhauling these machines is during their period of inactivity and before the rush of spring work. If put off until needed, delay incident to getting repair parts promptly, press of other work, and the hazy recollection of the past season's difficulties with that machine may hinder the efficient prosecution of this work.

At the end of the season's work with any machine it is a plan well worth while to make out a schedule of needed repairs and adjustments for that particular machine and file it in a convenient place, so when opportunity arises the work may be taken up and prosecuted expeditiously. The machine itself represents capital invested. It should be housed properly and not left in a fence corner or other out of the way place for wooden parts to rot and metal parts to rust, which, even for short periods, may cause more deterioration than the season's use.

When putting away, see that the knife bar is left clean and wiped with a greasy rag and stored in a dry place. Also place a block of wood or other support under the mid point of the tongue so that it will not acquire a permanent sag. If stored with the cutter bar in a vertical position, place a block of wood under the shoe to take the weight off the frame. All accumulations of macerated vegetable matter, dirt, and grease should be removed, and the bright parts oiled or greased.

REPAIR OF MOWERS.

Preparatory to overhauling, remove the machine to a vacant place on the shed floor where the light is good and the machine is readily accessible on all sides, or, if the weather is not inclement, to a shady place in the yard where the ground is fairly level. Have some definite system in going over the machine. The following is suggested:

Alignment of cutter bar.—With the tongue blocked up in normal position of use and lifting spring adjusted so that the inside shoe is just floating, test for alignment by stretching a string from the center of the pitman bearing through the center of the knife-head bearing to the outer end of the cutter bar. When properly aligned the outside end of the knife bar will lead the string by about 1 inch for a 5-foot cutter bar and about 1⅜ inches to 1½ inches for a 6-foot bar. The drag on the cutter bar when in use will cause it to drop back to a normal position.

Types of aligning devices differ with different makes of mowers. A common type is an adjustable rod joined to the frame or drag bar at one end, the other end joined to the front of the inside shoe. One end of the rod is threaded and one nut may be backed off. The nut on the other side of the fastening then may be run up to align the bar by rotating the shoe about the drag-bar connection. When proper alignment is secured these nuts should be tightened securely, that they may not work loose. One manufacturer uses an adjustment surrounding the rear hinge pin of the inside shoe. Each particular machine should be examined to see what provision is made and then adjustment may be made to align the bar and secure lighter draft.

Alignment of guards.—With the knife bar removed, guards which are badly out of alignment may be detected by sighting along the bar. The better way is to use a straight piece of strap iron or steel straight-edge 15 to 20 inches long and move it along on top of the ledger plates, noting which are high and which low. Drive guard out of alignment back into place by a sharp blow of the hammer at a point where the stock is thick. In replacing a broken guard by a new one the ledger plate may be too high. This can be remedied by putting tin shims between the guard and the bar when bolting on.

Dull ledger plates may be sharpened by removing the guard and grinding them on a stone, care being observed to preserve the original angle of shear. Broken ledger plates may be replaced and brought into line by shims, as for a new guard.

On stony ground the guard wing, the part which projects from the ledger plate, may become bent up, down, or sidewise. The function of this wing is merely to guide the cut grass out of the way of the knives. When bent they should be straightened to conform as nearly as possible to the new guard. Never bend down these wings to hold the knife against the ledger plates. If the points of the guards have become battered or blunted by use they may be taken off and ground to their original taper.

Adjustment of cutter-bar clips.—Examine the knife bar for kinks and bends and if present remove by straightening on a flat iron surface and put in the least worn knife bar, care being observed that sections are in alignment on the bar. If the cutter bar is provided with wearing plates, adjust these plates to take up the back and forward play. The knife bar should move freely by hand, yet have little play. Starting with the clip nearest the inside shoe, tap with light blows of a hammer so that the clip just barely begins to tighten on the bar. Loosen the clip and proceed with the other clips in the same manner. When all have been set, tighten down securely. The knife bar then should move freely by hand. Some machines are provided with adjustable wearing plates in the knife head. If so, this adjustment should be made when the cutter-bar wearing plates are adjusted. If no provision is made, or if too badly worn, the knife heads and wearing plates should be renewed, as excessive wear at this point frequently is the source of broken knife bars.

Outside shoe.—The grass end of cutter bars on many machines is supported by a shoe resting on the ground. This is adjustable for height and should be attached rigidly. When badly worn it should be renewed. If, as in the case of some machines, the grass wheel is present, this should be examined. This wheel has a slight lead away from the grass. If the bearings are worn so that it leads into the grass, they should be renewed. The swath boards or swathing sticks have a useful function to perform. The connection at the point of the attachment should move easily but not too freely. Broken swath sticks should be replaced at the proper angle.

Grinding knife section.—Every machine should be equipped with two knife bars and the extra one taken to the field, so that when one becomes damaged or dull it may be replaced by one in good cutting condition. In grinding knife sections try to preserve the same cutting angle and bevel as that found on the new sections. Most operators grind away too much of the point and too little of the heel of the section. Thus a condition is brought about similar to that of trying to cut a hardwood toothpick with a wide open pair of shears. The toothpick merely slides along the shear blade until the proper angle of shear is reached. If by use a section becomes very much shorter than adjacent sections, it should be replaced by a new one.

To remove sections, do not punch out the rivets, thus enlarging the rivet holes and weakening the bar, but place the vertical edge of the bar on a solid piece of iron having a square straight corner and long enough to reach the sections adjacent to the one which is to be removed. Strike a smart blow with a hammer on the back of the section at a point directly above the rivet. This shears the rivet neatly, and only the punch is necessary for removing the sheared rivet from the bar. In replacing sections a soft steel rivet of proper size and length should be used, so that the hole is filled entirely and a neat button head may be produced. Never use rivets that are too hard or attempt to improvise rivets from nails or old screws.

Centering of sections.—When sections are centered properly with a pitman on either dead center, the center point of the section should center with the center line of the guards. If the sections do not center, it may be remedied by lengthening or shortening the pitman rod or lengthening or shortening drag bar, if this adjustment is provided. Other centering devices may be present on different machines, and the operator should examine the particular machine to see what provision exists, and make adjustments accordingly.

Pitman rod and knife-head bearing.—This usually is a ball and socket bearing. If by lack of attention the sockets have become elongated or the balls worn elliptical so that the lost motion can not be taken up, the only remedy is to renew either or both the knife-head and pitman-rod bearing. The bearing should be adjusted so that there is no lost motion and be kept in this condition. When run for a considerable length of time in the same position of the tilting-lever notch a shoulder may be worn on the ball of the knife head. When shifted to another notch the bearing may bind at this point. About the only remedy is to adjust the socket bearing for the new tilting position. If this is not done, a broken piston rod may result, as well as a hot bearing.

Swivel joint and pitman wrist-pin bearing.—Play or lost motion at this point should be taken up if provision is made for adjustment. If none is made, these bearings, as well as wrist pins, if worn, should be renewed. If the front end of the crank shaft has much shake while being rotated, a new bearing for this shaft in the main frame should be supplied.

Main and countershaft gears.—On many machines provision is made for adjusting the mesh of the gears on the countershaft and main gears when worn. On some machines this is done by an adjustment which forces the countershaft in the proper direction to mesh properly. On others the main gear or countershaft gear itself is shifted by an adjustable collar or by placing washers behind the gear. If washers or gears are worn very badly, it may be necessary to replace either or both. See that the gear-control mechanism works smoothly and effectively. If any parts are badly worn, they should be renewed.

Drive wheels and pawls.—If there is excessive end play on the drive-wheel bearings, this should be taken up by adjustable collars usually provided on the main axle. Not to do so may result in broken pawls and pawl springs. Any accumulation of dirt or vegetable matter in the pawl boxes should be removed, and if the engaging faces of the pawls are worn unevenly it may be remedied by dressing the faces with a file.

General.—In general, tilting, hand, and foot lever connections, seat fastenings, and draft connections should be gone over to see that all fastenings are tight, lock nuts and cotter keys in place, and parts weakened by wear replaced. Special attention, especially in hilly regions, should be paid to draft and neck-yoke connections. On some machines the neck yoke is fastened to the tongue by eyebolts and riveted in place by washers. Through wear and exposure to elements these connections may be worn so much that while normally appearing safe they may give way at an inopportune moment and a serious accident to horses or operator result. An efficient operator of any machine acquires the habit of inspecting it frequently to discover loosened parts, lack of lubrication, hot bearings, etc.

Lubrication.—Inclosed gears run better when clean and lubricated with a stiff grease and graphite mixture. When not inclosed, lubrication may be detrimental, as it provides lodgment for grit and dirt. They should not, however, be allowed to become clogged with macerated vegetable matter and dirt. This applies to ratchet bearings as well.

Oil cups should be kept clean and care observed that the holes to the bearing are not caked with worn-out oil or dirt. At the beginning of the season's work it is desirable to remove from the bearings accumulations of caked and worn-out grease. This may be facilitated by flooding them with a few drops of kerosene oil. A wad of wool makes an excellent filter for filling the oil cups. Unlike cotton waste, it is not easily drawn into the bearings, is not subject to chemical action of lubricating oil, and does not become felted by use. A few drops of oil on the bearing surface of the knife bar when starting work with a new machine, or an old one when it has been overhauled, assist greatly in obtaining smoothness at these points. An efficient operator lubricates little and often those parts where the supply of lubrication can not be maintained by means of oil cups. In dry seasons when the knife bar gums badly a squirt can filled with water, which may be applied occasionally, will cut away the gummed accumulation more effectively than oil.

Painting.—Wooden parts last longer and do not give way at unexpected moments if the protective coating of paint is renewed occasionally. Moreover, the second-hand value of the machine is enhanced thereby. The best treatment for the wooden pitman is an occasional application of warm, raw linseed oil.

REPAIR OF REAPERS.

Fundamentally, a reaper is only a mower equipped with a table or platform, which is a segment of a circle in outline, for collecting limited quantities of the cut grain, and with a rake head whereby the accumulations known as gavels may be removed, either automatically or at the will of the operator. Therefore, what has been said regarding mowers applies as well to reapers. In addition, the following suggestions are made:

Rake head.—Braces to the rake head from the platform, if pin-connected, become slotted in the pinholes by wear. Also, the bolts through the rake-head standard and frame casting may have become loosened and worn. This condition allows the rake head to sway and to rotate in a jerky manner and subjects the driving mechanism to undue strains. It may be corrected by removing the worn pins and bolts and having new heads forged on the braces with holes to size, or by replacing the braces with new ones. Bolts through the frame casting should be renewed if worn, and drawn up tight.

Many makes of reapers have shear pins intended to break when extraordinary stresses are put upon the rakes by lodged grain, etc. If these are worn, they should be renewed. They are of nominal size and can be replaced by cutting pins of required length from bar stock, riveting over the ends to hold them in place.

The cam-track latches should work freely and close promptly. If the closing spring is weak, this should be renewed. Quite frequently, when the reaper is being used to cut forage crops, buckwheat, and other grains of a succulent nature, the cam tracks become coated with macerated vegetable matter. This should be removed by scraping with a dull knife or a flat piece of metal. In no case should the cam tracks be greased if there is a rolling cam follower on the rakes themselves. Greasing will cause the rollers to slip and become flattened. If by careless application of lubricant some of the oil should work down on the cam tracks, it should be wiped off and the tracks dusted lightly with grit. If the follower is a shoe, the cam tracks should be lubricated with heavy oil or grease.

Rakes.—Rakes should be adjusted so that both ends bear equally on the table and only enough to sweep the table clean when discharging the gavel. The middle guard is provided with an extension, the purpose of which is to prevent the rake teeth from being drawn into the knives by lodged grain. Under ordinary conditions the rake should clear this guard easily. Broken rake teeth should be replaced. A few extra ones should be kept on hand. Their cost is trivial in comparison with the time expended in improvising teeth from whatever material may be at hand. If, on replacing, the new tooth is longer than those adjacent, it should be trimmed to equal length so that a neat gavel may be discharged.

Timing of rakes.—Adjustment of time of rise of rakes can be made further rearward in some makes of machines by taking out the filler washers between the rake cam and rake standard, and further forward by putting in additional washers. Other makes may have some other device, or no adjustment may be present. The particular machine should be examined to see what adjustment is present and this adjustment made accordingly.

Inside divider.—This usually is provided with an adjustment whereby lodged grain or grain leaning toward the stubble may be guided into the rakes by moving the divider toward the standing grain. If broken or bent from contact with obstructions, it should be replaced or straightened.

Outside divider.—This usually is wood and provided with a projecting guard or nose piece. It should be attached rigidly, and if battered or blunted may be removed and restored to its original shape by grinding. Flexible strips of wood or metal often are provided for guiding the standing grain into the knives, and, if broken or bent, should be replaced or restored to their original shape. Any projections that obstruct the passage of the outside divider through the standing grain cause it to be pulled down, and slovenly gavels result.

Grain wheel.—This wheel should run parallel to the line of draft or be given a slight lead toward the stubble, never toward the uncut grain. Probably no part of the reaper is neglected as much as this and is so large a source of side draft. It should receive frequent attention as to lubrication, and when worn the bearings, and even the wheel itself, renewed. As the part to which the wheel bearing is attached is adjustable for height, care should be observed that the guides are attached rigidly and that there is as little play as possible. The fenders, if broken or bent, should be replaced or restored to their original shape.

Rake-head driving mechanism.—On some makes of reapers, this is done by gears from the countershaft, on others by sprocket and chains. Adjustment for wear of gears may or may not be present. An inspection will determine. For machines equipped with sprocket-chain drive a chain tightener is provided. Where the chain has been increased in length by wear, remove a link if possible, rather than attempt to take up the slack by extreme adjustment of the tightener itself. When replacing the sprocket chain see that the openings of the hooks are on the outside and that hook ends of the links lead in the direction of the travel of the chain. The chain itself should be lubricated with graphite or a heavy grease and graphite compound.

General.—In general, examine the tilting lever connections, gear shift control, trip lever connections, and raising and lowering devices. These should work easily, yet the lost motion should be taken up as much as possible. The fastenings should be rigid. Seat fastenings and draft connections should be examined to see that all are tight and that the lock nuts and cotter keys are in place.

Storage.—The table may be folded for road transport and storage. This is done very quickly and easily. The machine, when folded, takes up very much less space and the platform does not become distorted by being unsupported. When not in use and when not folded, the rear end of the platform should be supported by a short prop. The weight on the tongue also should be supported by sufficient blocking under it at the draft connection.

The remarks on mowers relating to lubrication and painting apply to reapers as well. The machine should be run in gear for a short distance before cutting operations are begun. This helps to loosen it up and better work will be accomplished at the start.

REPAIR OF BINDERS.

The binder is a more complicated piece of apparatus than either the mower or reaper. Yet by a little systematic study of the various parts and their relation to each other, an intelligent mastery of this machine is acquired readily. It carries the preparation of the unthrashed grain for transportation and storage one step farther than the reaper, in that it binds and bunches the gavels so they may be shocked readily.

The cutting mechanism is similar to that of the mower, and so far as this is concerned, the remarks under the head of mowers apply to binders as well. Unlike the reaper, which collects the gavels intermittently on a stationary platform, the binder is equipped with a moving canvas or belt which conducts the cut grain to elevating canvases, which in turn carry the grain to the binder deck, where it is packed into a bundle of required size and the bundle wrapped and tied with twine. Some binders have been built and operated successfully whereby the platform canvas carries the cut grain direct to the binding deck without elevating the grain over the drive wheel. This type of machine is, however, in the minority. Differing also from the reaper, the rake-head is replaced by a reel which has a wide latitude of adjustment in order to pick up grain leaning away from the machine and to operate properly in very long or very short grain. To put the machine in good working order and adjustment the following points should be covered:

Platform and elevating canvases.—Before replacing canvas, see that rollers work easily, that they are straight and in good repair, and that they are in proper alignment. If not properly aligned the canvas will not run straight. To determine if the canvases are squared properly a new machine may be tested with a carpenter's square. The frame of an old machine, however, may be sprung, and a better way is to test the lengths of the diagonals. If the diagonals are not equal they may be brought to equal length by shortening or lengthening the brace rods provided for that purpose. Canvases not squared properly run hard, slats are broken, and excessive wear on bearings results. The canvases should be run only tight enough to prevent slippage, and when the machine is not in use or left over night, they should be slacked off either by loosening the buckles on the canvas straps, or by slacking off canvas tighteners. In replacing canvas see that the buckles lead in the direction of travel. Examine the roller bearings and if worn, replace.

Split or checked rollers, but straight otherwise, may be repaired by forcing the split or checked portions together in a vise, drilling them and countersinking for small bolts. The countersunk heads and nuts should clear the canvas, and the rollers should be protected from crushing in the vise jaws by wrapping with paper or old sacking. After repair the rollers may be smoothed off with a file or sandpaper.

All broken slats and straps should be replaced by new ones. Examine the canvas stretchers to see that they are working properly.

Canvas driving chains.—Clean thoroughly by scrubbing with an old discarded horse brush or scrubbing brush after soaking for a short time in a bucket of coal oil or gasoline. Then rinse with clean coal oil or gasoline. In replacing chains see that the hooks are on the outside and that they lead in the direction of travel. Examine the sprocket gear bearings, clean out oil holes, and if bearings are badly worn, renew. See that the sprocket wheels are in line. This can be tested by sighting across the faces of the wheels. If there is excessive end play, take it up by placing washers back of the sprocket wheels. See that the chain tightener is adjusted properly; not too tight, but tight enough to prevent slapping of the chain. If the chain has increased in length from wear, remove a link, if possible, rather than adjust the tightener to an extreme position. The outside and not the inside of the chain should run over this wheel.

Outside divider and grain wheel.—See remarks under reaper, which apply to binder as well.

Reel.—See that the reel slats are in good repair and replace any that are broken or badly sprung. Connections to the arms and arm connections to the hub should be tight. The reels on most binders are placed so that the stubble end is given a lead ahead of the grain end. This is to counteract the tendency of the grain to elevate head end first. This tendency may also be overcome by attaching a thin strip of metal to the outside end of the platform, so that it lies on top of the canvas where the heads fall upon it. This retards the heads somewhat. A strap or rope also may be used for this purpose. To adjust the reel slats lower the reel and place the slats so that they clear the inside divider easily and run parallel to the platform canvases. To accomplish this it may be necessary to shorten the reel-post guide rod. In use, the skillful operator shifts the position of the reel to meet the varying conditions of the grain. It should be placed to strike the grain near the top and just far enough ahead to drop the grain onto the platform clear of the cutter bar. For lodged grain or grain leaning away from the cutter bar it will be necessary to place the reel further forward and lower, in order to pick up the grain and lay it over on the platform.

Examine the reel shaft bearings and if badly worn, renew. Some makes of machines employ a gear drive for the reel—others a sprocket and chain. If gear drive is used and is worn, examine for adjustment of gears for proper mesh and make the adjustment accordingly. In bevel gear drives, always secure the proper mesh by adjusting both gears equally. If renewals are necessary, renew both gears, as two worn gears or two new gears run with less friction than one worn and one new. If sprocket and chain drive are present, the same procedure may be followed as for canvas drive chains.

Examine the reel shifting lever connections to see that all latches work freely and positively. Take up lost motion wherever possible. Renew broken or excessively worn parts and see that all connections are rigid and tight.

Crown wheel.—Most makes of binders are driven by sprocket chain drive from a large sprocket, known as the crown wheel. This wheel is attached rigidly to the hub of the main, master, or bull, wheel, as the large drive wheel which carries the major portion of weight of binder, and which rolls on the ground, is variously termed. The crown wheel, by means of a heavy sprocket chain, drives the short shaft, known as the main shaft, which in turn drives the countershaft through bevel gears. The sprocket for driving platform and elevator canvases, packer, and binder shafts, and reel-driving mechanism is attached to the rear end of the countershaft. The crank or crank wheel and pitman are attached to the forward end. The clutch for throwing the machine in and out of gear usually is found on the main shaft.

The crown wheel should line properly with the sprocket wheel on the main shaft. This can be tested by sighting, or, better still, by placing the straightedge across the faces of the crown wheel and main-shaft sprocket wheel, care being observed that the crown wheel is not sprung and that it is bolted tight to the hub of the main wheel. If the main-shaft sprocket wheel is not in its proper position, it may be shifted into line.

The main chain should be removed, washed with gasoline or coal oil, and scrubbed free from all accumulations of dirt. When replacing see that it runs in the proper direction, hooks or flat side on the outside, and leading in the direction of travel. As the main wheel carries up a great deal of soil when rotating, it is not advisable to lubricate this chain with oil or grease. Dry flake graphite may be used, however. See that the tightener is in good repair and renew the tightener wheel and bearing if badly worn. This should be adjusted properly to take up the slack in the chain, but not too tight. Here, as in all chain drives, it is better to remove a link and shorten the chain rather than adjust the tightener to an extreme position.

Main wheel.—See that the main wheel is in the proper notch on the quadrant and square with the frame. When the binder is carried on transport trucks, the main wheel sometimes jumps out a tooth and does not run square with the frame when the binder is lowered into position for cutting operations.

Raising and lowering devices.—See that these work freely and that all fastenings are tight. If any parts are badly worn, renew.

Main shaft bearings.—If badly worn, renew. Flush occasionally with kerosene oil to remove worn out lubricants and other accumulations. See that they are being lubricated properly.

Countershaft and bevel gear drive.—Examine the bevel gears for the proper mesh, and if badly worn replace both gears with new ones. Improper meshing may be corrected by moving the bevel gear on the main shaft and also the bevel gear on the countershaft. Never make all of this adjustment on one gear in bevel gear drives but adjust equal amounts on each gear. Usually this may be done easily by means of a threaded end bearing on the countershaft and main shaft boxes. The particular machine should be examined to see what provision is made. Examine the countershaft bearings and if badly worn, renew. These also should be examined for proper lubrication, and flushed occasionally with kerosene.

Packer shaft, needle pitman, discharge arm shaft, etc.—These as well as binder attachments should be gone over in detail to see that all accumulations of vegetable matter are removed, oil holes free, and various parts work freely. Broken parts should be replaced and bent parts restored to their original form or replaced. Provision for taking up wear may or may not be made. Adjustments for proper operation usually are made to better advantage in the field. As such, they will be treated under another heading, " Bundles and tying troubles and their remedy."

General.—In general the tilting lever and connections, binder shifting levers, bundle carrier trip, butt adjuster lever, and reel shifting lever should be examined to see that they work freely and positively, that those parts showing excessive wear are renewed and all fastenings are tight. The main frame should be gone over to see that all connections are tight. Broken or bent frame braces should be renewed or straightened. Draft and seat connections should be examined to see that all are tight and that all lock nuts and cotter keys are in place.

During the harvest when it may not be convenient to put the binder under cover at the end of a day's work, the binding deck, elevator, and platform canvases should be protected from rain and dew with a tarpaulin, securely fastened down so that gusts of wind will not expose these parts to the elements.

Storage.—At the end of the season when preparing for storage, here, as well as with other farm machines, a list of the needed repairs and note of the season's difficulties with that machine should be made and filed in anticipation of the future, when repairs may be made more conveniently. A hazy recollection of the past season's difficulties and tardy receipt of repair parts will be obviated thereby, and the prosecution of the work will be facilitated. Trucks are provided for road and storage transport.

Some systematic plan should be adopted to prepare the machine for storage. Remove the canvases, wrap up carefully, and store in a dry place away from mice or rats, or hang them over a round stick with ends free and even and in a dry place. Thus mice and rats can find no place for nests.

Apply a good leather dressing, harness oil, or tallow to leather straps to prevent them from becoming dry and hard and cracking in use. Never apply a mineral oil to leather. The knife bar and wooden pitman should be removed and stored in a dry place. The knife bars should be cleaned and greased. The pitman should be stored on a shelf or flat place, so that it will not spring or warp. Grease the ledger plates, knotter, and twine holder, needle point, twine eyes, and all bright parts of the machine and binding mechanism in general. The chains also may be removed, cleaned (preferably in a bath of coal oil), wiped dry, and oiled. They should be labeled, tied in a bundle, and hung in a dry place. Some of the reel arms, as well as the tongue, may be removed if storage space is at a premium. If any wooden parts are removed, they should be stored in a dry place and in such a manner that they will not warp. In preparing a machine for storage, store all attachments in one place and all bolts and washers should be replaced in the part from which they were removed. If the tongue is not removed it should be supported by blocking at the draft connection so that it will not acquire a permanent set. The bearings throughout the machine should be oiled with a heavy oil which will not run out readily.

Painting.—As with mowers and reapers, wooden parts do not warp or decay as rapidly, and the second-hand value of the machine is enhanced if the protective coating of paint is renewed at the proper time. The reel slats and arms, outside dividers, tongue, neck yoke, whiffletrees, deck, guides, etc., come within this class. An application of warm, raw linseed oil will be better for the wooden pitman and canvas rollers.

Lubrication.—An efficient operator lubricates little and often those parts where a sufficient supply can not be maintained. No other farm machine demands so much attention in this respect as the binder. The operator should familiarize himself with the location of all oil holes and cups and prosecute this duty in a systematic manner so that no bearings are neglected. He should not squirt oil at random, trusting to chance that some of it will reach the bearing, but should see that all oil holes are clear, and apply only enough to effect the desired purpose. If by careless application oil is smeared over adjacent parts, the excess should be removed with a rag so as not to afford lodgment for grit, which may subsequently work its way into the bearing. When lubricating, watch out for loose bolts, parts out of adjustment, etc. An efficient operator readily detects any discordant note in the customary hum of the machine and remedies the trouble at once. A loose bolt or knock may cause the breakage of a part which, inexpensive in itself, may cause several days of expensive delay in the rush of the harvest season.

Oil cups should be packed with a filter of wool. This is more satisfactory than cotton. A few drops of oil on the bearing surfaces of the knife bar when starting work with a new machine or an old one that has been overhauled assist greatly in obtaining a smooth bearing at these points. Before starting cutting operations it is a good plan to run the machine in gear for a short distance if possible. This helps to loosen up the machine in general and better work will be accomplished at the start.

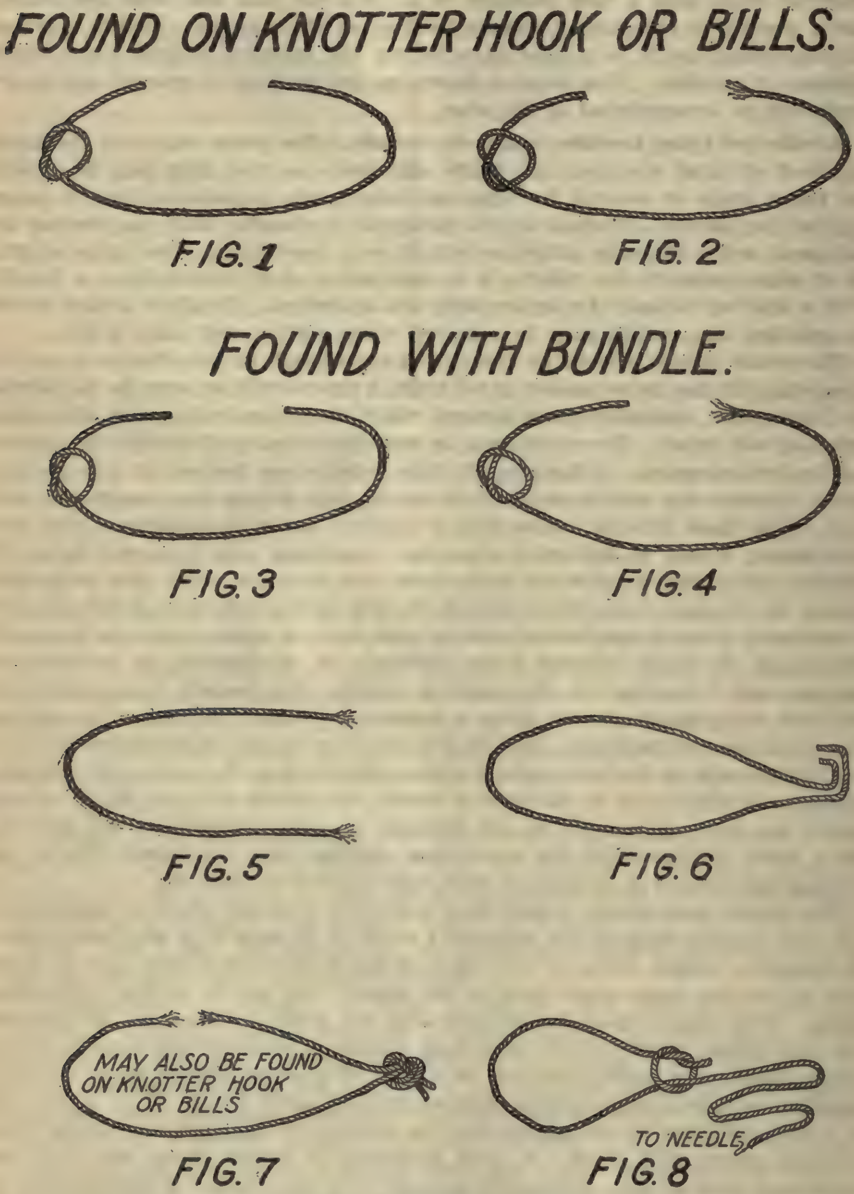
Bundle and tying troubles and their remedy.—The grain covers on the binding deck of most machines are made adjustable so that they may be raised for heavy grain or lowered for light and loose grain, in order to force it down against the packers. To bind at the middle of the bundle, shift the binding attachment rather than the butter, except for very short grain. The butter should be at right angles to the rollers; if it does not work in this position a bundle with a slanting instead of a square butt will be formed. Usually a header board is provided also, which may be removed when cutting very long grain.

The twine tension should be kept just tight enough to take the slack out of the twine. If the twine tension is too tight, a groove will be worn in the needle eye, twine disc, and other parts through which the twine is threaded, and tying troubles will result. Never attempt to regulate the size of bundles by adjusting the twine tension. If larger and tighter bundles are desired for ripe and dry grain, increase the tension on the trip spring, thus moving the compressor arm back. For those binders which have a separate trip and compressor arm, the trip spring should be tightened when the compressor arm is moved back. If smaller and looser bundles are desired for wet or green grain, this procedure should be reversed—i. e., the tension on the trip spring should be decreased, and if necessary to move compressor arm forward the trip spring should be loosened. Sometimes in heavy tangled grain difficulty is encountered in dischargnig bundles, and "choking" of the machine results. The remedy is to adjust the trip and compressor arm for tying a smaller and looser bundle, or by raising the grain cover of the binder deck slightly in order to give more clearance.

A binder will do its best work if tilting slightly into the grain. If unbound bundles are thrown out at the start of cutting operations of a new binder or one which has been overhauled do not attempt to make adjustment, but proceed for a short distance until the operator is satisfied that the trouble lies in the knotter and is not due to paint or rust, which will soon wear off.

The binder attachment proper is a somewhat complex piece of mechanism, yet with a little study of the particular machine in hand it is mastered easily. In replacing broken, worn, or bent parts of the binder attachment, bear in mind that all moving parts must work at the proper time and in unison with other parts. With this in mind, before removing any parts, examine the attachment for any timing marks which have been placed thereon by the manufacturer. These usually are projections cast on a pair of opposite cogs in gears meshing together, or may be some symbol stamped into the metal itself. If no marks can be found, difficulty in assembling may be obviated by making time marks with a small, sharp cold chisel. A good mechanic in taking down any piece of machinery does so in a systematic manner, with due regard to the relation of the parts, so that in assembling bolts and attachments are put back into the original position. If such care is observed, the original bearings are preserved and parts do not become loosened as readily by use.

If, after proceeding a short distance, the machine continues to discharge bundles without binding them, examine the twine knife. Like any edged tool this becomes dulled by use and should be sharpened occasionally. A small whetstone or a small mill file should be used for this purpose. Try to maintain the original bevel of the knife, with a clean, sharp cutting edge. Never use a file on the knotter itself. The trouble possibly lies somewhere else, and a systematic inspection of the bands usually will determine its location. All knotter-head adjustments should be made gradually. If too great changes are made, the proper set of the parts will be missed and other troubles will result.



Examples of defective binder ties.

If the band (fig. 1) is found clinging to the knotter hook or bills with the free end cut off square, it indicates that the twine disc is too loose or the twine tension too tight. The remedy is to loosen the tension, and if this does not correct the trouble tighten the disc spring slightly.

If the band (fig. 2) is found on the knotter hook or bills with loose end ragged or crushed, loosen the twine tension, and if this does not remedy the trouble loosen the disc spring slightly.

If the band (fig. 3) is found with the bundle with a single knot in one end, but the free end cut off square, tighten the disc spring, and if this does not overcome the difficulty examine the disc for wear. If badly worn the only remedy is to replace the disc with a new one. If this occurs regularly with each fifth, sixth, or seventh bundle, look for wear in one notch of the disc. A very loose or broken twine tension may be the cause of the twine not being stretched tightly across the knotter hooks or bills.

If the band (fig. 4) is found with the bundle with a single knot in one end and the free end ragged or crushed, the twine tension is correct, but the disc spring is too tight. The remedy is to loosen the disc spring.

If the band (fig. 5) is found with the bundle, but both ends free from knots and straight, and each end ragged and crushed, the tension is right, but the disc spring is very tight. The remedy is to loosen the disc spring.

If the band (fig. 6) is found with the bundle, but both ends free from knots, and folded, showing that the knot was formed but not completed, examine the knotter hook or bills. The knotter hook or bill spring may be too loose or the hook or bills worn so badly that the ends were not held sufficiently tight to form a knot. The remedy is to tighten the knotter hook or bill spring, or, if excessive wear is present, replace the knotter hook or bills and shaft complete.

If the band (fig. 7) is found with the bundle, or clinging to knotter hook or bills in some cases with the knot perfectly formed but the band broken, the trouble may result from the knotter hook or bill spring being too tight when tieing loose bundles. The remedy is to loosen this spring slightly, or set the trip and compressor arm to bind larger and tighter bundles. It may be caused also from a worn cam roller on the stripper arm. The remedy is to supply a new stripper arm complete.

If the bundle is tied with a slip noose (fig. 8) with the twine extending from the discharged bundle to the needle eye, the needle has failed to place the twine in the disc holder, because of excessive wear in the needle eye itself. If the needle eye does not have a special wearing piece, the only remedy is to supply a new needle. In replacing the needle the point should protrude slightly above the deck when the needle is at rest.

As applying to some makes of machines, sometimes the bundle is tied properly but with a bowknot in one end. This knot simply includes the short piece of twine which other makes of machines cut loose and which is lost by the machines that tie a hard knot. This knot withstands rough handling as well as a hard knot, and is not an apparent waste of twine. Knotters properly adjusted will not handle twine that is not reasonably uniform. The remedy is obvious.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO THE CARE OF FARM IMPLEMENTS.

PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Trenching Machinery Used for the Construction of Trenches for Tile Drains. (Farmers' Bulletin 698.)

Economic Study of Farm Tractor in Corn Belt. (Farmers' Bulletin No. 719.)

Care and Repair of Farm Implements, No. 3. (Farmers' Bulletin No. 946.)

Care and Repair of Farm Implements, No. 4. (Farmers' Bulletin No. 947.)

Dust Explosions and Fires in Grain Separators in Pacific Northwest. (Department Bulletin No. 379.)

How Engineering May Help Farm Life. (Separate 660 from Year Book 1915.)

PUBLICATIONS FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Cream Separator on Western Farms. (Farmers' Bulletin No. 201.) Price, 5 cents.

Corn-Harvesting Machinery. (Farmers' Bulletin No. 303.) Price, 5 cents.

Repair of Farm Equipment. (Farmers' Bulletin No. 347.) Price, 5 cents.

Farm Experience With the Tractor. (Department Bulletin No. 174.) Price, 5 cents.

Excavating Machinery Used in Land Drainage. (Department Bulletin No. 300.) Price, 15 cents.

Machinery Cost of Farm Operations in Western New York. (Department Bulletin No. 338.) Price, 5 cents.

Width of Wagon Tires for Loads on Earth and Gravel Roads. (Secretary's Circular No. 72.) Price, 5 cents.

Corn-Harvesting Machinery. (Office of Experiment Stations Bulletin No. 173.) Price, 10 cents.

superseded by Leaflet no. 485

THE RAG-DOLL SEED TESTER

ITS USE IN DETERMINING WHAT EARS OF CORN ARE FIT FOR SEED

GEORGE J. BURT H. HOWARD BIGGAR
and CLEMENT E. TROUT
Scientific Assistants, Office of Corn Investigations

Ready for the Test

FARMERS' BULLETIN 948
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. February, 1918

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1918

ALMOST every fall, hard freezing weather in one or more sections of the United States catches the corn crop in an immature condition and injures or destroys the ears for use as seed. The latest and sappiest ears are often killed, while other ears, somewhat drier, have but a portion of the kernels killed. Frequently there are some ears so mature and dry that they are not injured or but slightly injured. Under such circumstances the uninjured ears are suitable for seed. By inspection they can be separated from the green ears that were killed. However, some of the ears that appear mature and sound have been killed or badly injured. To separate these ears from those that give a good germination, it is necessary to test the germination of a few kernels from each ear.

The rag doll has proved a convenient and satisfactory way of making these germination tests. An effective method of making and using the rag doll is here described.

THE RAG-DOLL SEED TESTER.

TESTING SEED CORN.

VARIOUS kinds of apparatus for testing seed corn are for sale by commercial firms. Others may be manufactured at home with simple materials. Some of these testers, such as the sand-box tester and sawdust-box tester, are described in various publications of the Department of Agriculture and the State agricultural experiment stations. The rag-doll seed tester has proved to be one of the most convenient and satisfactory forms. It is also one of the least expensive testers.

THE RAG-DOLL TESTER.

The cheapest material which has given entire satisfaction is bleached muslin. The muslin should be cut into strips 16 inches wide and from 3 to 5 feet long. With a pencil or crayon draw a line down the center of the strip. Leaving at least 4 inches at the ends, mark the strip crosswise every 4 inches. Number the sections and the tester will appear as shown in figure 1. Moisten the tester before putting the kernels upon it. Number the ears and place them in definite order. From different places on ear No. 1 take out 10 kernels and place them in section No. 1. Similarly take 10 kernels from ear No. 2, place them in section No. 2, and continue in this manner until every section

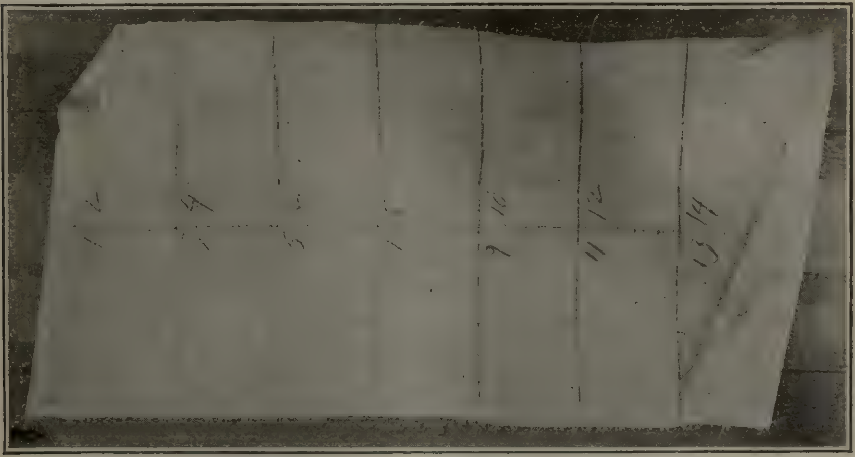

FIG. 1.—Cloth marked off, ready for kernels.

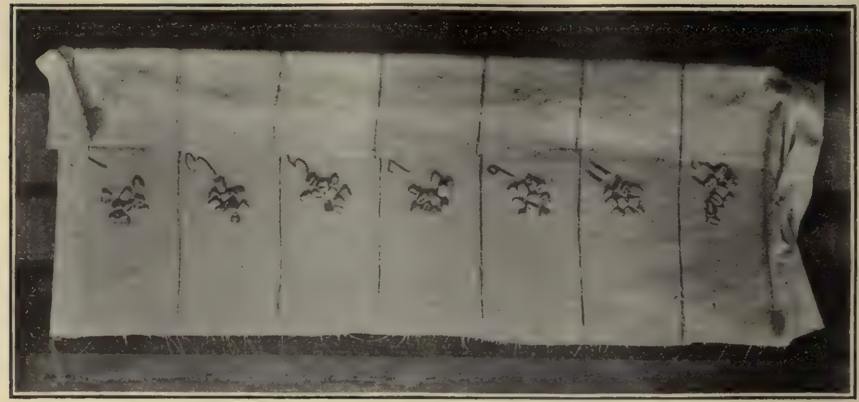

FIG. 2.—Kernels in place, one flap folded.

of the tester has been filled. Care should be taken to place the kernels some distance from the dividing lines, so that slight displacements caused by handling the tester will not mix the samples. Fold each side of the tester over, so that the edges meet in the middle. The method of folding is shown in figure 2. Press the cloth down firmly over the kernels, and, using a cob or some other cylindrical object as a core, roll the tester, as shown in figure 3. Tie a cord or slip a rubber band around the middle, and the doll is complete, as shown in figure 4.

The dolls should be thoroughly immersed in lukewarm water. From 2 to 4 hours have been found sufficient for the soaking, and it is best not to soak for more than 10 hours. Remove the dolls from the water, allow them to drain, and place them where they may be kept warm and moist. During the germination period the dolls should not be subjected to a temperature higher than 100° or lower than 50° F. A temperature between 80° and 90° F. during the day and 50° and 60° during the night will give good results. It is not advisable to give the dolls a second soaking. A good way to prevent drying out is to wrap them up in a piece of wet sacking or put them upright in an ordinary water bucket and cover them with a wet cloth. In either case, provision must be made for draining off excess moisture. At the end of five days, with temperatures approximating those recommended, the kernels should be sprouted sufficiently to show their fitness for seed. If any sample has a noticeably weak germination or has more than two dead kernels, the ear from which the sample was taken should be discarded.[1] Figure 5 shows both good and bad germinations.

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[1] There may be times, such as the spring of 1918, when the supply of good seed corn is extremely limited. In such seasons, it is well to retain all ears showing a germination of 60 per cent or more. The poorer germinating ears will have to be used if the supply of seed germinating 80 per cent or better is not sufficient. Keep the poorer seed separate and if it must be used, plant it thicker than the rest.

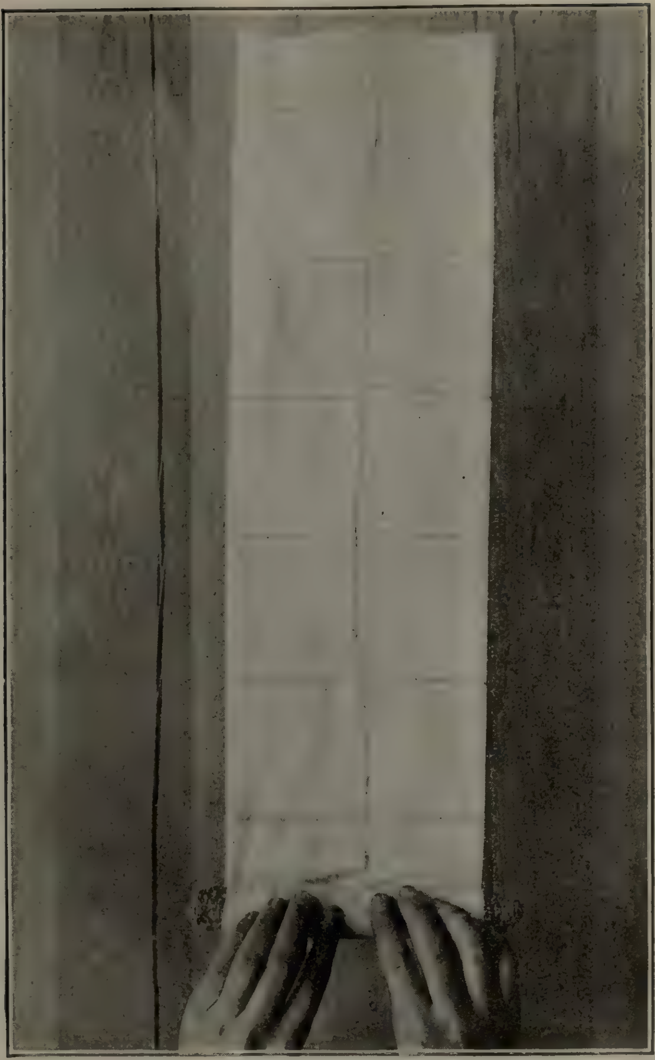

FIG. 3.—Rolling the rag doll.

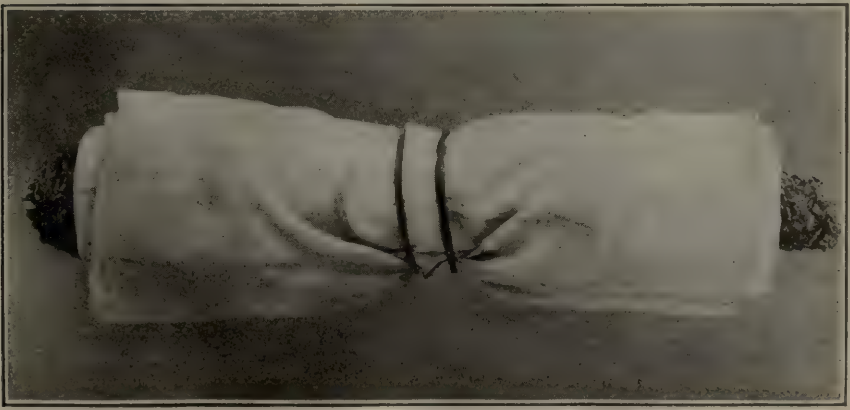

FIG. 4.—Rag doll ready for soaking.

If the dolls are to be used over again, they should be thoroughly scalded in order to destroy any mold growth.

CONCLUSION.

Of course, the testing of the germination of each ear is some trouble. However, to obtain a successful corn crop it is work that must be done by those who have not retained seed corn of good germination

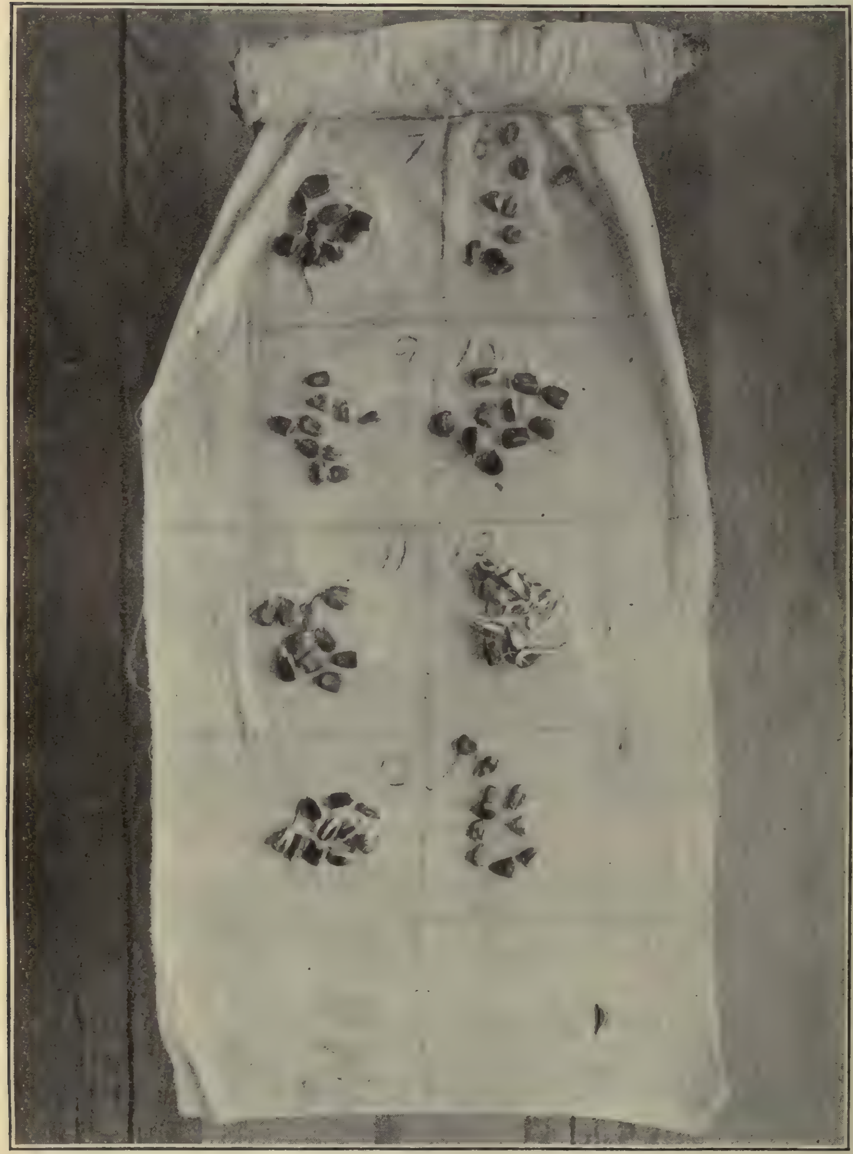

FIG. 5.—Results of the ear test. Note the difference in germination. Some have failed entirely, some have only a weak germination, while only one is a desirable seed ear.

from a previous crop. The holding over of good seed corn from a crop that matured thoroughly makes it possible to continue the improvement and adaptation of a strain without losing seed and is less troublesome than the making of separate ear germination tests. The use of the rag doll, therefore, is not recommended as the best practice possible, but as the most satisfactory way of getting suitable home-grown seed when a supply has not been held over from a good crop and fall-freezes have occurred so early as to injure the germinating power of the crop.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO SEED TESTING AND CORN PRODUCTION.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Corn Cultivation. (Farmers' Bulletin 414.)
Seed Corn. (Farmers' Bulletin 415.)
How to Grow an Acre of Corn. (Farmers' Bulletin 537.)
A Corn-Belt Farming System Which Saves Harvest Labor by Hogging down Crops. (Farmers' Bulletin 614.)
Corn Culture in the Southeastern States. (Farmers' Bulletin 729.)
Corn Growing under Droughty Conditions. (Farmers' Bulletin 773.)
Corn in the Great Plains Area: Relation of Cultural Methods to Production. (Department Bulletin 219.)
Tests of Corn Varieties on the Great Plains. (Department Bulletin 307.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

The Production of Good Seed Corn. (Farmers' Bulletin 229.) Price, 5 cents.
The Germination of Seed Corn. (Farmers' Bulletin 253.) Price, 5 cents.
Harvesting and Storing Corn. (Farmers' Bulletin 313.) Price, 5 cents.
School Lessons on Corn. (Farmers' Bulletin 409.) Price, 5 cents.
Testing Farm Seeds in the Home and in the Rural School. (Farmers' Bulletin 428.) Price, 5 cents.
Grades for Commercial Corn. (Department Bulletin 168.) Price, 5 cents.
Farm Practice in the Cultivation of Corn. (Department Bulletin 320.) Price, 15 cents.
How Seed Testing Helps the Farmer. (Separate No. 679, Yearbook, 1915.) Price, 5 cents.

Many of the State agricultural colleges have free bulletins on seed testing.

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DEHORNING AND CASTRATING CATTLE

FRANK W. FARLEY

Animal Husbandry Division

FARMERS' BULLETIN 949

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Animal Industry

JOHN R. MOHLER, Chief

Washington, D. C. April, 1918

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DEHORNING cattle makes it easier to handle the animals and insures that each one will have a more equal chance at the feed trough when placed in the feed lot.

It renders the animals harmless to attendants, and prevents them from goring one another in the feed lot or in transit to market. Goring in transit causes a greater shrinkage in weight, injures the skin for commercial purposes, and leaves the flesh in a bruised condition, which naturally detracts from its value.

The removal of the horns makes for more uniformity in the appearance of a bunch of cattle either in the feed lot or in the herd.

CASTRATION of bull calves not intended for sires is very important, because if they are allowed to run too long they become troublesome, begin to look "staggy," and lose the refinement desired in feeder steers.

The quality of flesh obtained from the carcass of the steer is superior to that which would have been obtained if the calf had been allowed to remain a bull.

The operation removes inferior or scrub bulls from the herd and retains them for feeders.

DEHORNING AND CASTRATING CATTLE.

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SCOPE OF BULLETIN.

THE EXPERIENCED stockman is familiar with all the operations and methods that are outlined in this bulletin; it is therefore to the small stockman or the man who is just starting in the cattle business that this bulletin is designed to be helpful. It is intended to present some facts and explain certain methods of dehorning and castrating clearly and concisely so that they may be easily understood. The article is not designed in any way as a treatise on either of the two subjects.

The farmer who maintains only a medium-sized farm herd of cattle can not devote his entire attention to them as the ranchman does, but must give a part of it to other farm duties; therefore it is to his advantage, ordinarily, to dehorn, castrate, brand, and possibly vaccinate all at the same round-up.

DEHORNING.

The practice of dehorning cattle is almost universal so far as high-grade beef steers are concerned. The majority of feeders and practically all the well-finished steers that appear on the markets of to-day have been dehorned. It is often desirable to dehorn the heifers as well as the steers, especially where they are to be fed in troughs for a part of the year. Various methods have been followed and various devices used in dehorning. In some instances the cruel practice of throwing the animal on the ground and chopping its horns off with an ax has been followed, while in other instances, and especially on the western ranges, dehorning chutes of heavy timbers have been constructed and the horns removed with an ax or a saw. At the same time numerous concoctions have been used for applying to the wound made by removing the horn.

In this bulletin are shown illustrations and plans of a simple, convenient, and secure dehorning chute that has proved to be very satisfactory. The expense of building a chute of this kind is very small, and the chute can be conveniently arranged and used for castrating, branding, and vaccinating as well as for dehorning.

In general the purposes to be accomplished by dehorning are:

1. To make the animals more easily handled.
2. To insure that each animal has an equal chance at the feed trough when placed in the feed lot.
3. To render the animals less dangerous to attendants, and to prevent their goring one another in the feed lot or in transit to market, which causes a greater shrinkage in weight, injures the skin for commercial purposes, and leaves the flesh in a bruised condition, thus detracting from its value.
4. To give more uniformity to the appearance of the bunch of cattle.

In the dehorning operation the horns may be removed either when the calf is only a few days old, by means of a caustic, or, when the horn is either partially or wholly developed, by sawing or clipping. The latter may be done any time after the animal is past four months of age.

USE OF CAUSTIC FOR YOUNG CALVES.

A simple and easy though not always practicable method of dehorning is to use a caustic on the undeveloped horns when the calves are only a few days old. Either caustic soda or caustic potash may be used. These come in sticks about the size of a lead pencil and may be purchased at any drug store.

The main objection to this method of dehorning is that it requires too much attention on the part of the stockman. Calves, coming as they do in seasons when there is a rush to get crops either planted or harvested, are almost certain to be neglected and some will become too old for the use of the caustic. However, if the calves are kept in a pen or separated from their mothers a part of the time there should be no difficulty on this score. Another objection to the use of caustic is that more pains must be taken than is necessary in cutting off the horns with a saw or clippers. The method of using the caustic is very simple, however, and if a few precautions are observed no trouble should result.

To obtain the best results the operation should be performed when the calf is from 4 to 10 days old. At this age the knob or bud is only loosely attached to the skull and appears more as a part of the skin. The hair should be clipped off over and around the horns and vaseline applied around the edge of the hair. This is to prevent the caustic from spreading and causing a sore on the skin adjacent to the horn. The end of the stick of caustic is then slightly moistened and rubbed on each horn alternately three or four times, allowing it to dry each time before applying to the next. The stick should be wrapped in paper with one end exposed, as the caustic will burn the hands if it gets on them. Extreme care should also be taken not to have the stick so wet that the solution from it will run down the side of the calf's head. Neither should the operation be done when there is a likelihood of rain in a few hours, unless the calves are to be kept under shelter, because the rain will wash the caustic down into the hair over the face and possibly into the eyes, causing a severe burn and probably loss of sight. When the caustic is properly used a scab will form over the bud and drop off within a few days.

When the operation is successfully performed with caustic potash it leaves the head in better shape than when done later with saw or clippers. This is especially desirable in heifer calves that are to be kept in the breeding herd.

DEHORNING WITH SAW OR CLIPPERS.

After the horns of calves have reached a certain size it becomes necessary to cut them off. Saws and clippers are the two common instruments used for this purpose. The clippers are quicker and less painful to the animal, but the saw does not crush the horn as do the clippers, especially in the case of old animals whose horns have become hard and brittle. On the other hand, when the saw is used there is not so much bleeding, as the action of the saw causes the blood vessels to be lacerated, and a clot of blood forms quickly.

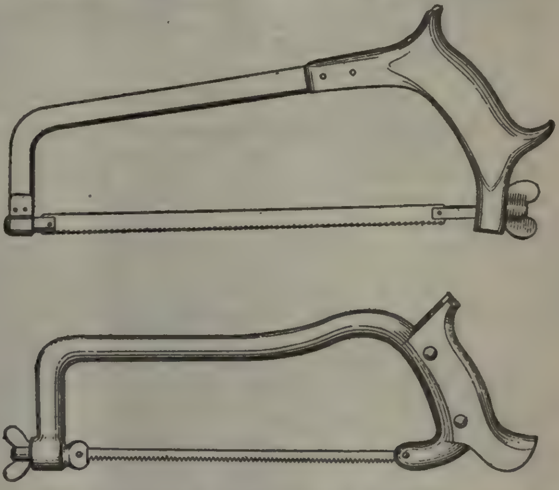

FIG. 1.—Dehorning saws. These saws are light and convenient. A one-inch blade is the most satisfactory because it is not so liable to run to one side in the horn. The blade should be kept tight to avoid this trouble.

Clippers give very good results with young cattle, but with old animals the saw should be used, as the crushing of the hard bone in an older animal causes the bone to sliver, which makes a wound that heals very slowly. The loss of blood from older animals will also be more likely to cause trouble than with younger animals. Although some stockmen prefer using the clippers altogether, it is much safer to use the saw altogether than it is to use the clippers altogether. A desirable compromise would be to use the saw on the hard, brittle horns of the older animals and the clippers on the soft, tender horns of the younger animals.

Whichever instrument is used, care should be taken to cut enough of the horn to insure that unsightly stubs will not grow out. From one-eighth to one-half inch of skin should be taken off to insure this. (See fig. 4.) When this is done the horn-forming cells are probably destroyed, which prevents further growth of horns. If none of the skin is taken off the stubs of horns will grow out and sometimes are almost as effective in hooking as the original horn. Occasionally, too, such a stub will grow down into the eye of the animal, which makes it necessary to perform the operation again.

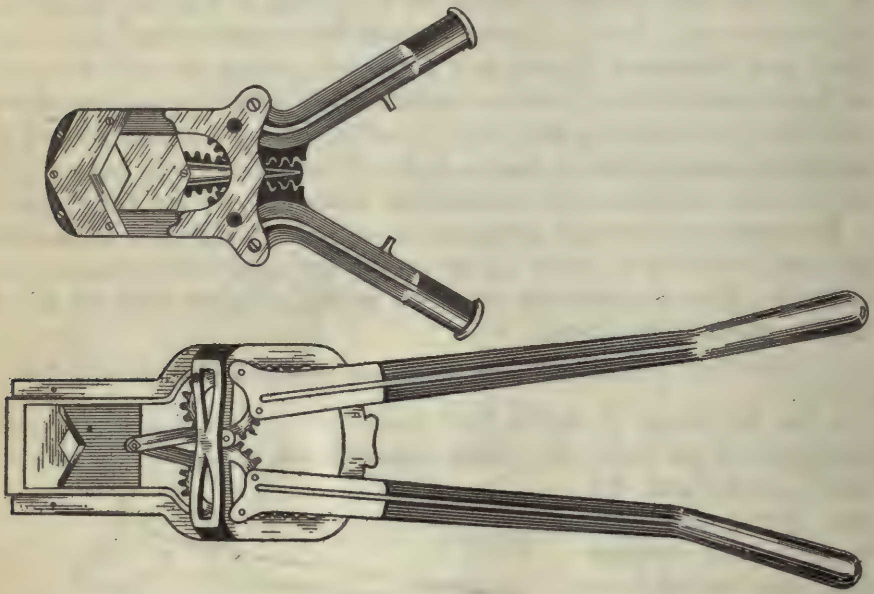

FIG. 2.—Dehorning clippers. The cutting edges are formed of two V-shaped knives which come together and give four cutting surfaces. When the handles are pulled together the horn is cut in four different places, which lessens the tendency to crush the horn, common with square-edged blades.

TREATMENT AFTER DEHORNING.

Cattle should never be dehorned during warm weather, that is, weather that is warm enough to cause danger of the wound becoming infested with screw worms. If there is any danger of flies whatever, some fly repellant should be applied to the wound immediately after the animal is dehorned. Either coal tar or pine tar is very satisfactory. Both are nonirritating and adhere well to the skin and the wound. Whichever of these is used, if too thick to apply conveniently, may be thinned with fish oil or linseed oil. Either an ordinary paintbrush or a swab made by tying a rag on a stick may be used to apply the tar.

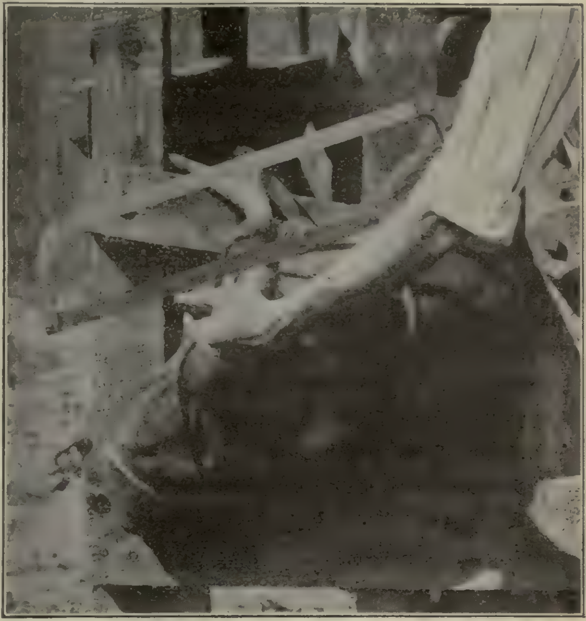

FIG. 3.—Correct position for removal of horn.

The practice of placing a piece of cotton outing flannel over the wound made by dehorning, as advocated by some stockmen, usually meets with poor results, except possibly when the cattle are to be turned into fields where they will be exposed to burs or to severe winds. In such cases the cloth protects the wound to some extent. Ordinarily it requires too much time and trouble, and not 50 per cent of the cloths will stick after they are put on. The practice of using a hot iron to sear the wound and stop the bleeding is not practicable nor is it necessary.

If in spite of all precautions the wound becomes infested with screw worms they may be removed by saturating a piece of absorbent cotton with chloroform and inserting it into the wound, or by pouring gasoline into the horn cavities. The chloroform or gasoline will kill the screw worms, after which they may be removed with a pair of forceps, a probe, or by forcing the animal's head to one side and allowing them to drop out. Carbolic acid or some other efficient disinfectant may be used for killing the

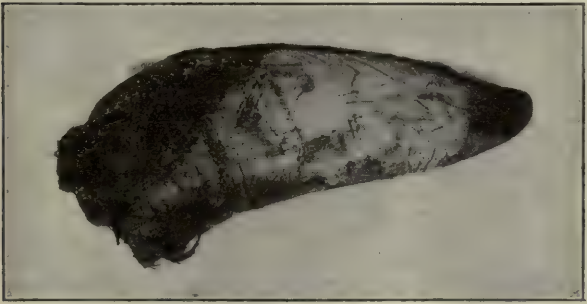

FIG. 4.—Horn after proper cutting. Note hair and skin attached.

worms, but these are not so effective as chloroform or gasoline. If the carbolic-acid solution is used, add 3 tablespoonfuls of the acid to a quart of water. A stronger solution than this is liable to injure the skin or the tender tissue of the wound. This solution can be applied with a syringe or by using a brush or a swab.

After the worms have been removed either pure pine tar or one of the coal-tar disinfectants in proper dilution may be applied.

DEHORNING CHUTES—PLANS AND METHODS.

In drawing the accompanying plans for dehorning chutes (figs. 7, 8, 9, and 10) it was convenient to show all material sawed to dimension; however, this does not mean that sawed lumber must be used in constructing the chute. Rough posts and scrap planks of different dimensions may be used, provided the posts are smooth enough to nail to and the scrap planks are of sufficient strength to hold the animal.

Figures 5 and 6 show front views of two types of chutes. Both are very successful when properly built. The head clamp in both types is operated from the side by means of a lever as shown in the drawings. In figure 5 the position of the lever and head-clamp bars, when open, is represented by dotted lines. A short rope is attached to the end of the lever for pulling it down and fastening it when closed. The lever may be of any length desired, but should not be so long and heavy that it will not allow the clamps to open with their own weight. The arms fastened to the top of the head-clamp bars may be made of strap iron $1\frac{1}{2}$ to 2 inches wide, in which case four bars are used. Wood also may be used, in which case only two bars are used, one on each side of the lever. The lower arms are best made of wood. When the head-clamp bars are closed they should be about 4 inches apart. Four-inch blocks should be placed between the two bars at the crosspieces to hold them steady.

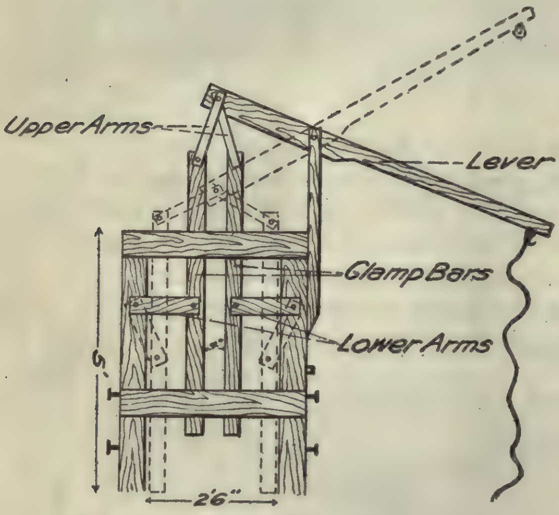

FIG. 5.—Plan of dehorning chute, front view.

Figure 6 shows the front view of the second type of chute. The drawing shows one side made sloping. The advantage of this is that the bottom may be made narrower. This works better for smaller animals, and large animals are not so likely to get down. The dotted lines show the position of the head clamp when open. To hold the clamp closed, the lever is notched on the underside and works in a loop with a bolt or pin through it so that the notches will drop over it. A pin or bolt is inserted in the hole in the crossbar at the top to hold the other head-clamp bar. For small animals this clamp bar is left closed. This type of chute is easier to construct than the one shown in figure 5, but will not permit the cattle to pass out through the front.

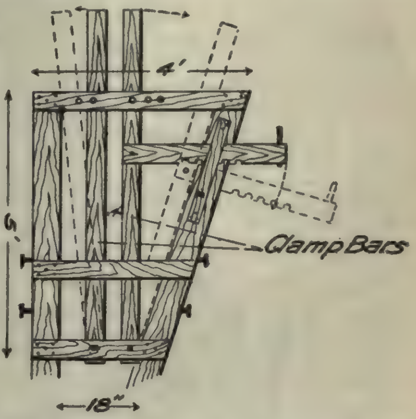

FIG. 6.—Another type of dehorning chute with sloping side.

Figures 7 and 8 show the sides of the chute, which may be used for either type. The gate is convenient for letting the animal out of the chute and may also be used to advantage in vaccinating. It may be placed on whichever side is most convenient, except that it can not be placed on the sloping side of the type shown in figure 6.

After the animal is in the chute and the head clamp is closed, a bull ring should be placed in its nose, or a loop placed around the neck and a noose slipped on its nose; the head is then pulled around and the end of the rope fastened to the pin shown on the side of the front post. This forces the animal's head to one side, so that the outside horn will extend forward, which makes it convenient for sawing or clipping. After one horn is taken off the head can be forced to the other side by fastening the rope to the pin in the opposite post.

CASTRATION OF CATTLE.

The primary reason for castrating bull calves and making steers of them is that the quality of the flesh of steers is superior to that of bulls, and bull calves that are allowed to run too long without being castrated lose the refinement desired in feeder steers.

A very important result of castrating, aside from the increased value of the animal from a beef standpoint, is that it removes inferior or scrub bulls from the herd.

TIME TO CASTRATE.

It is very important that bull calves be castrated before they become troublesome and before they begin to look "staggy." Calves from a week to 6 or 8 months old may be safely castrated. If the calf is too young, however, the testicles are undeveloped and may be difficult to secure, while if more than 8 months old severe hemorrhage may result which may terminate fatally. The usual time to castrate calves is when they are about 4 months old.

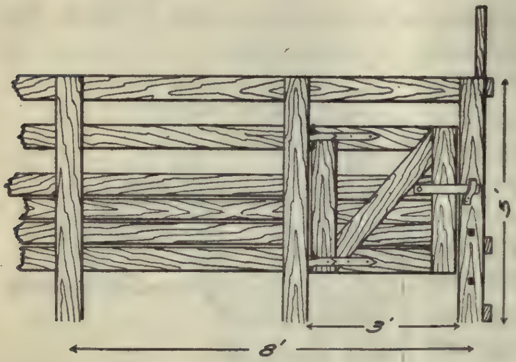

FIG. 7.—Side of dehorning chute, showing gate.

A dry, cool day during a period when grass or forage is plentiful should be selected, if possible, but the operation should not be delayed too long because of the lack of these conditions. The calf may be castrated in the dehorning chute at the same time he is being dehorned, or he may be thrown to the ground for the operation.

THROWING THE ANIMALS.

On the range the common method of throwing an animal consists in casting a noose around the fore leg and tightening it quickly. This causes the animal to fall. Another method is to place a rope around the animal's neck and another around its hind legs. Both ropes are then tightened and an assistant throws the animal by "tailing" it. The animal can be secured on the ground by tying the rope on its neck to a post at one end of the pen and the one on its hind legs to a post at the other end of the pen, or the fore and hind legs may be brought together as far as possible and tied securely. The latter method is known as "hog tying."

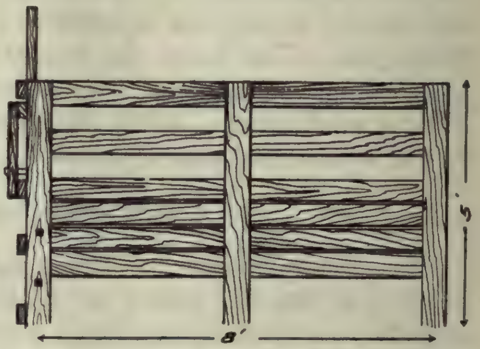

FIG. 8.—Side of dehorning chute without gate.

MATERIALS REQUIRED.

The only implements necessary for castrating are a sharp knife and a pan containing a 3 per cent solution of a standard disinfectant. An ordinary pocketknife with a medium-sized blade will do.

If the scrotum or bag is filthy it should be thoroughly washed with the disinfectant, otherwise this will not be necessary. The knife should be kept in the disinfectant at all times when not in use.

METHOD OF OPERATION.

There are two ways of making the incision, depending upon whether or not it is desired to make a fancy feeder of the calf. The first method consists in grasping the scrotum with the left hand and cutting off the lower one-fourth or one-third. This should expose the ends of both testicles, but if one of them can not be seen it can usually be pushed out by pressing on the abdomen by the side of the scrotum. The testicles may then be pulled out one at a time and removed. About 1 inch of the cord should be removed with the testicle to prevent the severed end from protruding from the incision. In young calves the cord may be cut off directly, but in older calves the cord should be stretched over the forefinger and scraped with the edge of the knife until it parts. This lacerates the ends of the cord and serves to reduce the hemorrhage. A safer way of severing the cord is by the use of an emasculator, an instrument shaped like a pair of pliers with a broad, corrugated crushing surface and a cutting edge (fig. 11). With this instrument the cord is cut and at the same time so lacerated as to cause a minimum of bleeding. The écraseur (fig. 12) is another instrument for severing the cord. With this the crushing is accomplished by a chain loop which is placed around the cord and slowly tightened until the cord is severed. The latter instrument gives the best results, but the emasculator permits of quicker work.

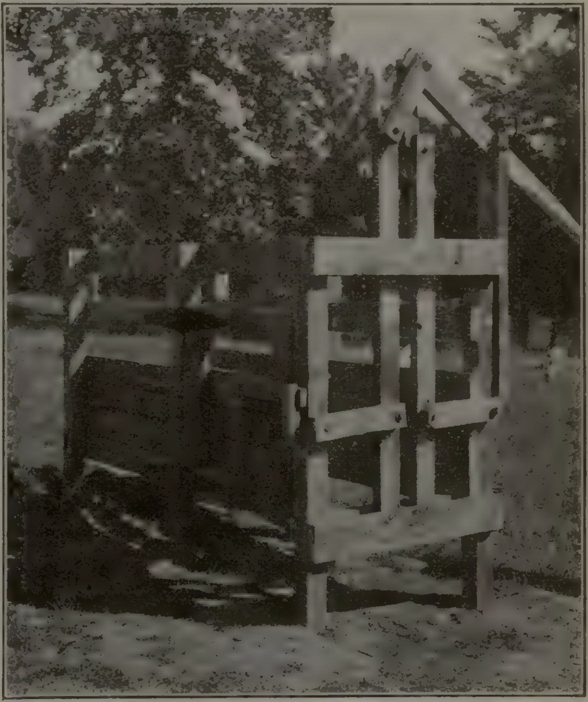

FIG. 9.—View of chute with head clamp closed, showing side gate.

The second method consists in slitting the scrotum parallel to the median line which divides the two sides, instead of cutting off the end as in the first method. The cuts are made directly over the middle of each testicle. The testicles are then taken out through the separate cuts and removed as already described. In this operation care should be taken to make the cuts clear to the end of the scrotum in order to insure perfect drainage from the wound.

The first method is just as satisfactory as the second, except in the case of fancy feeders that are to be shown at fairs, when it is desirable to have a large cod or purse which will be filled with fat when the animal is in high condition.

CASTRATION OF LARGE ANIMALS.

If a large animal is to be castrated he may be restrained in the same manner as described for calves. Greater precautions, however, should be taken to prevent too much bleeding, as there is a considerable hemorrhage from the cord in older animals. For this reason it is advisable to use the emasculator or the écraseur for severing the cord. In the absence of these instruments the cord may be seared off with a red-hot iron, care being taken to protect surrounding parts from the heat; or it may be scraped as described before.

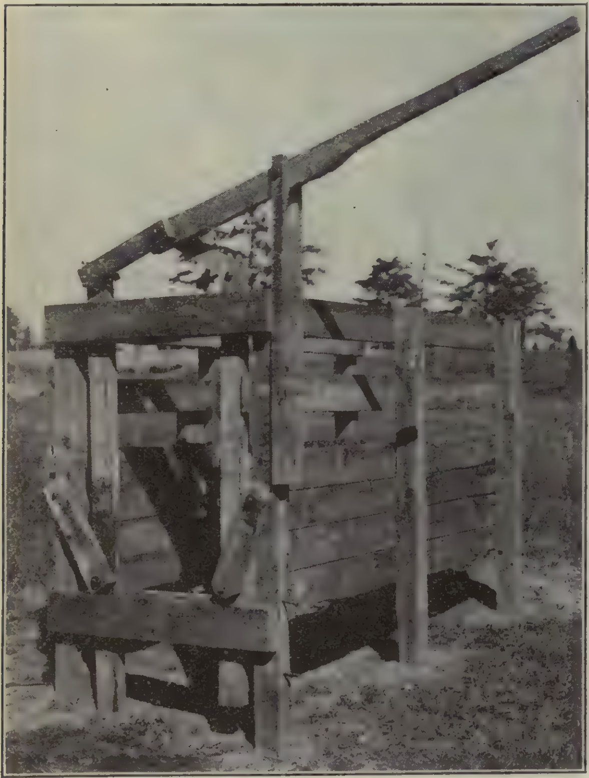

FIG. 10.—View of chute with head clamp open, showing position of handle.

AFTER-TREATMENT.

Ordinarily no after-treatment is necessary. The animals should be turned into a pasture as soon as the operation is completed, as there is much less danger of infection of the wound in a pasture than around pens or barns.

If the operation is performed during fly time, pine tar should be applied to the wound to keep off the flies. Unless the wound becomes infested with screw worms or maggots no trouble will ordinarily result. Should this occur a simple treatment consists in saturating a piece of absorbent cotton with chloroform and inserting it into the wound, or in filling a pint cup with gasoline and allowing the cod to dip into it. The chloroform or gasoline kills the worms, after which pine tar should be applied to prevent further infestation.

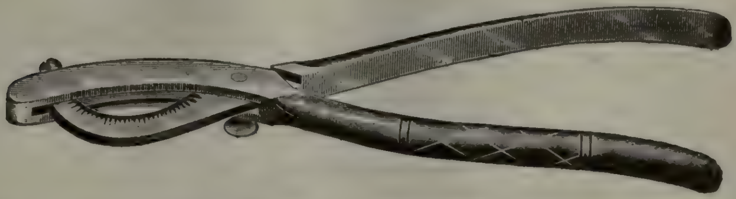

Fig. 11—Emasculator. This instrument has a broad, corrugated, crushing surface and a cutting edge. It is applied to the cord, severing it with little loss of blood.

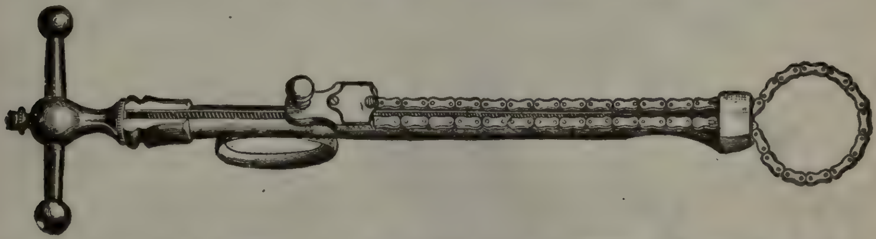

Fig. 12.—Castrating écraseur. The chain loop of this instrument is passed around the cord attached to the testicle and gradually tightened by slowly turning the handle. The cord is thereby slowly crushed and severed, so that very little blood is lost.

When a mature bull is to be castrated or a calf is ruptured a competent veterinarian should be called in, as the operation is too serious for the average stockman.

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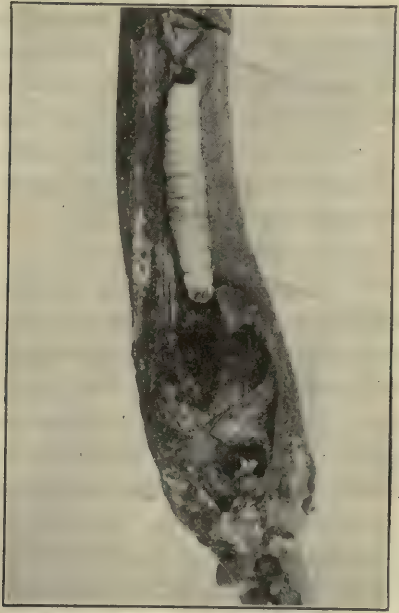
THE SOUTHERN CORN ROOTWORM AND FARM PRACTICES TO CONTROL IT

PHILIP LUGINBILL
Entomological Assistant
Cereal and Forage Insect Investigations

Rev. 1940



FARMERS' BULLETIN 950

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. May, 1918

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OF ALL CORN PESTS in the South one of the most serious is the larva, or young, of the 12-spotted cucumber beetle—the so-called southern corn rootworm. True to its name, it feeds on the roots, but in young corn it also drills a small hole in the stem just above the first circle of roots, boring out the crown and killing the bud. Attacked plants either die outright or are so badly stunted as to be unproductive. Lowland corn suffers the most and injury is greatest during cool, damp seasons. The adult, or beetle, is also exceedingly destructive; not, however, to corn, but to cucumber, squash, and a great variety of other truck crops and ornamental plants.

Progressive farming methods, as described in this bulletin, will reduce the ravages of this insect. Burn over waste places to destroy dead grass, weeds, and rubbish in which the beetles winter. If possible, avoid planting corn in fields which contained corn the year before. Enrich the soil by planting legumes so that the corn will have a better chance of recovering from rootworm injury. Protect the bobwhite. This bird destroys many beetles of the rootworm. By careful observations, extending over a period of years, find out the dates between which the rootworm does the most damage; then time your planting so that it will fall either before or after these dates, taking into consideration, of course, other important factors in crop production.

THE SOUTHERN CORN ROOTWORM[1] AND FARM PRACTICES TO CONTROL IT.

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ECONOMIC IMPORTANCE AND COMMON NAMES.

CORN GROWERS in the Southern States suffer damage from the southern corn rootworm (fig. 1) practically every year. In fact, as a serious corn pest in the South the rootworm has few competitors. During some seasons it is quite a difficult matter to get a stand of corn in the lowlands on account of these worms. During years of heavy infestation it is necessary to replant corn as many as three times and even then only a poor stand is obtained. The loss that may be attributed to the ravages of the pest is probably even greater and more far-reaching than is commonly supposed. Very often weather conditions are blamed for the yellowish and sickly appearance of corn and the resulting poor yield of the crop, when in reality the true cause is southern corn rootworm injury.

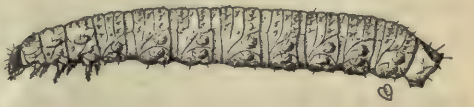

FIG. 1.—Southern corn rootworm: Larva or worm, side view. About four and one-half times natural size.

Although this rootworm sometimes damages the corn crop in the more northerly sections of the Middle West, it is not there considered a serious corn pest. A closely allied insect, the western corn rootworm,[2] takes its place as an enemy of corn in these regions.

---

[1] *Diabrotica duodecimpunctata* Olivier; order Coleoptera, family Chrysomelidae.

[2] *Diabrotica longicornis* Say.

The southern corn rootworm is more commonly known as the "budworm"; in fact, few farmers know it under the former name. It is sometimes termed "drillworm." These names are more or less descriptive of the injury done to the plant by the worms. The adult, or parent, is known as the 12-spotted cucumber beetle, from the fact that it has 12 black spots on its back and is often a serious enemy to cucumbers and allied plants.

GEOGRAPHICAL RANGE OF THIS AND RELATED ROOTWORMS.

The southern corn rootworm has a very wide distribution. It is found throughout the greater part of the United States from Maine to Florida, and from the Atlantic coast to the Rocky Mountains. It occurs also in Mexico and Canada. It is not recognized, however, as a serious pest of Indian corn north of Maryland and the southern parts of Ohio, Indiana, and Illinois, south of Georgia, or west of the Mississippi River, with the exception of parts of southeastern Texas and southern Louisiana. (Fig. 2.)

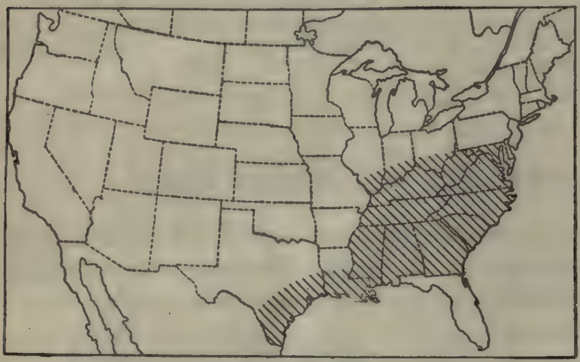

FIG. 2.—Map showing, by shaded area, region where corn is most seriously injured by the southern corn rootworm.

The western corn rootworm[1] occurs from Maine to the Gulf of Mexico and westward to Minnesota, South Dakota, and New Mexico.

In the States bordering the Pacific occurs a closely allied species.[2] This western rootworm is often injurious to various cultivated crops. In southern Texas there is still another species, the belted cucumber beetle,[3] which sometimes does practically as much damage to corn in that region as the southern corn rootworm.

WHEN SERIOUS INFESTATIONS MAY BE EXPECTED.

Serious infestations of the rootworm may be expected during seasons of abundant rainfall and cool weather, conditions conducive to the development of this insect. Corn in lowlands is more seriously affected than that in uplands, as this insect prefers to breed in moist soil. Thus it is only during years of heavy infestation that corn in uplands is subject to serious damage.

---

[1] *Diabrotica longicornis* Say.

[2] *Diabrotica soror* LeConte.

[3] *Diabrotica balteata* LeConte.

INJURY TO CORN BY THE ROOTWORM.

The worm or larva stage (fig. 1) of this insect is the one most injurious to corn. As the name "corn rootworm" would indicate, it feeds on the roots of corn, but it does not confine its injuries to the roots; indeed, the greatest damage to young corn is that done by the worms in drilling a small hole into the stem directly above the first circle of roots (see title-page illustration) and feeding on the interior, boring out the crown and killing the bud. Plants affected in this way break off at the injured point when an attempt is made to pull them. In older corn the worms injure the roots almost exclusively.

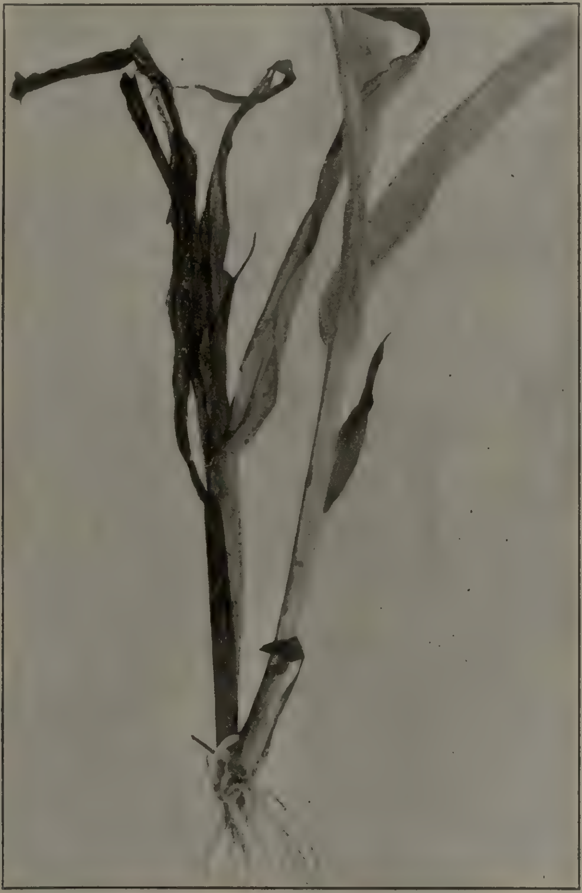

FIG. 3.—Corn plant showing injury by southern corn rootworm to growing point or "bud."

HOW INJURY TO CORN BY THE ROOTWORM CAN BE RECOGNIZED.

When young corn has been damaged by this insect the fact can be easily detected. The bud leaves of injured plants, having been cut off from the main plant, dry up and die (fig. 3), while the rest of the plant retains its original color for a time. Subsequently the whole plant dies if injured badly. It is on account of this peculiar manner of injury that the insect is often called the "budworm."

Larger plants when attacked present a sickly yellowish and dwarfed appearance, due to the fact that the worms are feeding on the roots. Very often such plants exhibit a number of suckers, and they produce little or no grain.

DEVELOPMENT.

The southern corn rootworm has four distinct stages through which it passes in development. The first is the egg, the second the worm or larva, the third the pupa or transformation stage, and the fourth the adult, parent, or beetle.

EGG STAGE.

The egg (fig. 4) is oval and about the size of a large pinhead. It is dull yellow when freshly laid, but later turns a deeper yellow. Its surface is covered with extremely small, shallow pits which in outline resemble a six-sided figure. Eggs are deposited by the female beetle in contact with or near the corn plants, slightly below the surface of the ground. Their number varies greatly. Over 400 may be laid by one individual and as many as 100 in one day. Eggs usually are deposited in early evening. They hatch in from 6 to 8 days, the length of the egg period depending upon temperature conditions. Upon hatching, the worms attack the stems and roots.

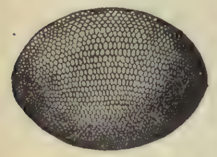

FIG. 4.—Southern corn rootworm: Egg greatly enlarged.

WORM OR LARVA STAGE AND LARVAL FOOD PLANTS.

The worm (fig. 1), or larva, is slender and yellowish-white, with a dark-brown head and a dark patch on the top of the last body segment. It tapers toward the head end, the last few segments of the body being much wider than the head, which makes them appear as if swollen. It is quite active, even when young, and it is only with great difficulty that it can be captured when crawling about in the soil. When just hatched from the egg it is so small that it is barely perceptible to the unaided eye, but when full grown it can be seen readily, as it is then about one-half inch in length.

Upon examining infested or injured corn the worms may be found in their tunnels or among the roots. Sometimes, however, they are found some little distance away from the injured plants, probably migrating to other corn plants in the same row.

In addition to corn the larvæ of this species are known to feed and live on the roots of Johnson grass, Southern chess,[1] wheat, millet, rye, young oats, and alfalfa.

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[1] *Bromus unioloides.*

PUPA OR TRANSFORMATION STAGE.

After the worm is full grown it enters the ground to a depth varying from a few inches to a half foot or more, the actual depth depending upon the texture of the soil. It then makes a cell somewhat oval in outline and smooths it very evenly on the inside. Presently it begins to shorten, and after an interval of a few days it sheds its skin and passes into the pupa or transformation stage.

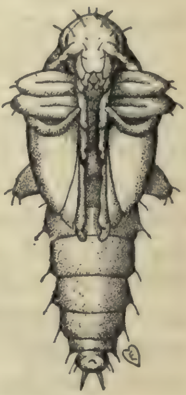

FIG. 5.—Southern corn rootworm: Pupa or resting stage. About eight times natural size

A clear conception of what the pupa is like can be formed by examining figure 5. In this stage the insect can not move from place to place and is not destructive. It never leaves its cell. The only part capable of movement is the tip of the abdomen, which is moved about violently when the pupa is disturbed. The pupa is soft, yellowish, and about one-fourth of an inch in length. It is a little longer than the width of its broadest part and has two very conspicuous spines at the tip of the abdomen.

The pupa stage lasts about 10 days and then the 12-spotted beetle, or parent, comes forth and works its way through the soil to the surface of the ground.

PARENT OR BEETLE STAGE AND FOOD HABITS OF THE BEETLE.

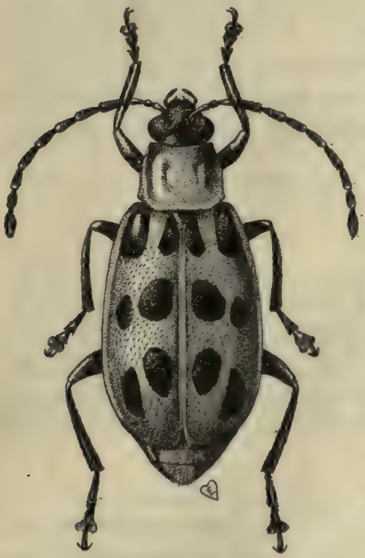

FIG. 6.—Southern corn rootworm: Adult or beetle. About eight times natural size.

The parent or beetle (fig. 6) is about one-fourth inch in length, yellowish-green, with a black head and legs and, as previously stated, with 12 black spots on the back. These spots are irregular in outline and generally somewhat separated.

The beetle is very active during warm weather and can be captured only with difficulty. When feeding, if danger threatens, it falls to the ground and crawls away under rubbish or hides under the foliage of smaller plants. During cool weather it becomes less active, and when the temperature is near freezing it scarcely moves, even when disturbed.

In the beetle stage the insect is quite destructive—not, however, to corn but to certain truck crops such as squashes, cucumbers, etc., and on account of the fact that it is such a serious enemy of these plants the beetle is known as the 12-spotted cucumber beetle. The injury to these plants consists of numerous small holes in the leaves, and if the plants are small and have only a few leaves a great deal of harm is done unless preventive measures have been taken.

In relation to corn the beetle stage is important as being the egg-laying period of the insect, for the female, after having mated, places her eggs in the soil near the corn plants.

HOW THE INSECT PASSES THE WINTER.

The southern corn rootworm passes the winter in the beetle stage, except possibly in southern Florida and Texas. In northerly regions the beetles go into hibernation late in the fall; that is, they crawl under rubbish and to other places that afford them protection from the cold and remain in an inactive condition during the winter. With the return of warm weather they again become active. In the more southern States, where temperatures are mild, they do not become torpid in the winter, but during cool days and nights hide under rubbish, among dead grasses, or under low-leaved plants and resume activity when the weather again becomes warm. There are some native plants which remain green throughout the winter in the South and beetles have been found feeding on them, as well as on rye, oats, and other field crops, during warm days in midwinter.

NUMBER OF GENERATIONS ANNUALLY.

The exact number of generations of this species as yet has not been determined definitely for any one locality. There appear, however, to be at least two generations in the North and three in the South. As a pest of corn in the South the first two generations only need be considered, and as a rule most of the damage is done by the first generation of the year.

NATURAL ENEMIES.

NATIVE BIRDS.

A number of our native birds prey upon the adults, or beetles, of the southern corn rootworm. Some of the common ones are the bobwhite, red-headed woodpecker, nighthawk, cardinal, kingbird, and phœbe. Of these birds the bobwhite deserves special mention. As many as 12 of the beetles have been found in the stomach of one bobwhite.

INSECTS.

The southern corn rootworm has only a few insect enemies, the chief one being a two-winged fly[1] (fig. 7) which attacks it in the beetle stage. This fly places a maggot, or larva, in the abdomen of the beetle, and the maggot feeds on the vital organs of the host and finally kills it. After the death of the beetle the parasite larva, being full grown, enters the ground and forms a tough, leathery case in which it passes into the next or pupa stage. This case, termed puparium, is dark and covered with needlelike spines. From the puparium there emerges in due time the adult, or fly, which starts the cycle again. This parasite is not very common and thus far has not played a very great rôle in the destruction of the pest.

---

[1] *Celatoria diabroticae* Shimer.

PREVENTIVE AND OTHER CONTROL MEASURES.

Although no one method has been discovered which, when applied, will eradicate this pest, yet if the following measures are diligently carried out the ravages of this insect can be reduced markedly.

BURNING OVER WASTE PLACES.

Large numbers of the beetles are destroyed by burning over waste places, such as the borders and terraces of fields. This should be done in the winter-time and on cool days. Beetles at that time and on such days congregate among dead grasses, seeking protection from cold. The value of this measure is realized when one considers that the killing of one female in winter is as important as the destruction of from 400 to 500 worms in the spring.

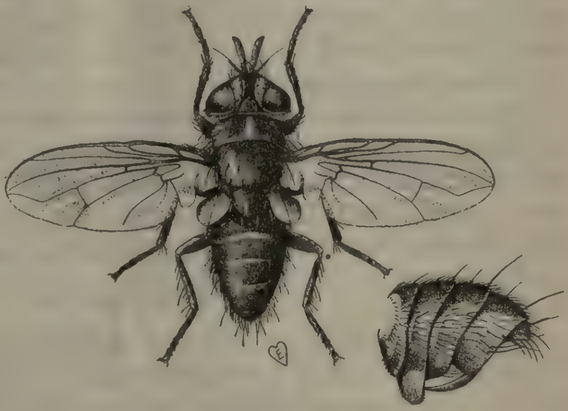
FIG. 7.—A fly enemy of the southern corn rootworm. At the right is shown the piercer by means of which the fly deposits a maggot within the adult or beetle of the rootworm. Fly about eight times natural size.

CROP ROTATION.

Judicious crop rotation should be carried on wherever possible. It is not well to follow corn with corn. There are several crops that are not injured by these worms, the foremost of them being cotton. Some of the smaller grains are only slightly injured and can, therefore, be used to good advantage in the rotation.

THICK PLANTING.

It is a common practice among some of the planters in the southeastern States who are acquainted with rootworm injury to plant corn thicker in the lowlands than in the uplands. Double the number of grains are dropped in low ground. This offers twice the chance of securing a stand and is to be recommended especially for fields which consist partly of low ground. The upland in such cases may be planted in the regular way. In fields of large area this measure loses its value, for if planted thickly some thinning may be necessary and this may mean a loss of labor, time, and money.

ENRICHING THE SOIL.

It is to be remembered that soil rich in plant food will produce plants that are more hardy, healthy, and capable of resisting insect attack than soil which is not so supplied. Plants injured by the "budworms" sometimes recover and the chances are that a larger percentage will do so in rich than in poor soil. Legumes should rank high in the rotation. They will add to the soil the much desired humus as well as store in the soil the valuable nitrogen extracted by these plants from the air.

It has been found that lowlands supplied abundantly with animal fertilizers are more seriously affected by these worms than those not so treated. It is well to make use of commercial fertilizers in such cases. This does not, as believed by some, repel the insects, but affords a less favorable breeding place for the pest.

TIMELY PLANTING.

The time at which the corn is planted affects, to a certain extent, its likelihood of escaping rootworm injury. There seems to be a period during which the worms are very active and do much damage. This period varies considerably with the latitude, being somewhat earlier in the extreme South than in more northerly regions. It has been found that corn planted during the latter part of March and after May 10 is less damaged than is that planted during April and the first week in May. There were exceptions, as some corn planted in late March and after May 10 suffered badly, but the largest acreage of injured corn was planted between the dates given.

In each locality, also, these periods naturally will vary somewhat from year to year depending upon the seasonal weather conditions. Every farmer, however, by careful observation extending over a period of years may discover when planting should take place so as to minimize the ravages of this pest, taking into account, of course, other important factors in crop production.

Investigations are now being conducted, in cooperation with the State entomologists of North Carolina and Florida, with a view to the determination of the importance of the time of planting as a factor in "budworm" control.

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